EVALUATION OF INRIVER TEST FISHING PROJECTS, BRISTOL BAY, 2000-2001

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ABSTRACT

Four Bristol Bay inriver test fish projects were evaluated: Kvichak, Egegik, Ugashik and Igushik Rivers. Gillnets are drifted at these sights prior to high tide to estimate sockeye salmon abundance that has entered the river but not yet reached counting towers located upstream. Abundance estimates are based on daily indices, which come from catch per unit effort (CPUE) information of the drifts. Inriver fish abundance is estimated using (1) travel time analysis in which the most recent cumulative tower count is divided by cumulative inriver test fish indices and lagged back in time by daily increments and (2) the mean fish per index (FPI) value of previous years. Evaluation of these projects consisted of examining previous site location, gillnet mesh size used and fishing times. In addition, seasonal factors (e.g. site bathymetry, water temperature, water turbidity, river discharge, crew experience, escapement abundance, escapement age composition and average length of fish in the escapement) were examined to determine how they affect inriver fish abundance estimates and if they can be used to improve estimates. Also, travel time using daily and cumulative escapement, maximum likelihood and regression techniques were examined to see which produces the best inseason estimates for each river. Analyses indicated that alternate site locations did not produce noticeably better estimates, current mesh sizes appear efficient, and drifting should occur 15 min sooner than traditional times at Ugashik River. Changes in river bathymetry, water turbidity and crew experience were never quantified, and water temperature had no obvious affect on test fish results. River discharge, escapement abundance and escapement composition (age and average length) were significantly correlated with test fish results at some of the sites. Evaluation and experimentation with modeling procedures suggested the travel time method using cumulative escapement information could be improved upon by using daily escapement numbers.

KEY WORDS: Sockeye salmon, *Oncorhyncus nerka*, inriver test fishing, inriver abundance estimation, fisheries management, Bristol Bay

INTRODUCTION

The Bristol Bay Management Area supports the largest sockeye salmon *Oncorhynchus nerka* fishery in the world. The ten-year average (1992-2001) of the total sockeye salmon run to Bristol Bay is 37.2 million fish and total harvest has averaged 26.3 million fish (West 2002). Large numbers of sockeye salmon return to Bristol Bay over a four to six week time period, making it one of the most intense salmon fisheries in the world. Sockeye salmon in Bristol Bay are managed on an escapement goal range policy, with escapement goal ranges set for individual rivers. Fishery managers control the commercial harvest to meet these goals by limiting time, area, and gear used by commercial fishermen. The most important information used by managers to meet these goals are estimates of total fish that have returned to date. This total return is composed of catch and escapement. Catch estimates are obtained from the processing companies. Estimating the number of fish that have escaped the fishery to spawn is often difficult. Tower sites used to enumerate escapement exist on many of the rivers; however, it takes several days for fish to reach these sites once they have entered the river. With the condensed run timing in Bristol Bay, fish numbers in excess of spawning goals can enter the rivers on one or two tides without the timely application of emergency order fishing periods. Inriver gillnet test fish projects are used to estimate the number of fish that escaped the commercial fishery but are still below the tower site, or what is called estimated river fish (ERF). This is accomplished by drifting gillnets above the commercial fishery and using catch per unit effort (CPUE) information, correlated with tower escapement information, to estimate river fish. These real-time estimates of fish numbers are critical to making timely decisions to manage for escapements within biological escapement goal ranges.

Inriver test fish projects currently exist at three sites: Egegik, Kvichak and Ugashik Rivers (Figure 1). These projects have operated on the Kvichak River since 1960, on the Egegik River since 1963 and on the Ugashik River since 1961 (Paulus 1965; McBride 1978). A fourth inriver test fish project operated on the Igushik River from 1976-1989 and from 1991-2000 (Crawford et al. 2002). Several changes in gear, fishing sites and methodology have occurred since the inception of these projects. Test fishing stations have gradually been moved from directly inside the commercial fishing district boundaries to their present locations several miles upriver. There has been a general trend toward shorter nets and a decrease in mesh size and fishing times at each site. The fishing gear has changed from 50 fathoms of 13.65 cm (5-3/8 in) mesh gillnet for Kvichak, Egegik, and Ugashik Rivers to 25 fathoms of 12.70 cm (5 in) mesh for Kvichak and 25 fathoms of 13.02 cm (5-1/8 in) mesh for Egegik and Ugashik Rivers. Test fishing on the Igushik River began with a single 25 fathom 13.65 cm (5-3/8 in) mesh gillnet fished as a setnet from shore and was later changed to a 25 fathom, 13.02 cm (5-1/8 in) mesh drift gillnet. Fishing duration has changed from 30 min per drift to <15 min. Fishing time relative to high tide has varied from 1.5 hours before each low slack tide to 15 minutes before each high slack tide. All projects currently begin drifts 1.5 or 2.0 hours before high slack tide. These locations and methods have not been changed or evaluated since 1985 when (a) mesh sizes were reduced from 13.65 cm (5-3/8 in) to the current mesh sizes and (b) the Kvichak River site moved upriver approximately 10 km (Bue et al. 1988; Stratton et al. 1990).

The purpose of this project is to review and evaluate the test fish equipment, techniques, and sites to ensure that these projects are providing the best possible inriver fish estimates to fishery managers and to determine whether any changes are necessary for improving the abundance estimates of sockeye salmon located between the fishing districts and the counting towers. More accurate inriver fish estimates will improve fishery management precision. We will evaluate the fishing times and mesh sizes used at the current sites, as well as test the performance of the current sites against alternate sites. We will chart the river bottom to look for any structure that may negatively impact test fish results. We will also explore how seasonal factors (e.g. river bottom bathymetry, water temperature, water turbidity, water discharge, crew experience, escapement abundance, escapement age composition and average length in the escapement) affect test fish results.

Early in the run, managers must make decisions regarding fishery openings with little available information. For example, there are usually few, if any, previous commercial fishery openings and no tower counts, which provide valuable information on the strength of the return. Therefore, many early season management decisions are based almost entirely on the information provided by inriver test fisheries. Unfortunately, inriver test fisheries have not performed well when tower counts are not available for calibration. Improving pre-tower count estimates of escapement offers the greatest improvement to the test fishery performance in Bristol Bay. We will explore ways to improve inseason river test fish estimates prior to obtaining tower counts.

Timely and accurate inriver fish estimates from test fishing are an integral management tool for achieving escapement goals. The inriver test fisheries perform better when tower counts are available, but the accuracy of the estimates of escapement have varied significantly over the years (Crawford et al. 2002). We will explore ways to improve in-season estimates of river fish by relating it to the current season's tower count data.

METHODS

Alternate and Existing Site Comparison

Alternate Site Selection

Alternate test fish sites were selected on the Egegik and Ugashik Rivers in 2000. These rivers were chosen over the Kvichak River because the existing Kvichak site has traditionally produced more accurate escapement numbers than the other sites. The Igushik River was not chosen because of its location and the fact that the continued existence of the project was in question after the 2000 season. Two sites were chosen at the Egegik and Ugashik Rivers on opposite riverbanks in close proximity to the existing sites. Sites were chosen based on channel characteristics, trial drifts, and fish behavior. Channel characteristics were determined by visual observations at low tide. Drift patterns were determined by drifting nets at the proposed fishing sites before high slack tide. Fish behavior was examined by observing where fish were getting captured in the net in relation to current direction, depth off the bottom, and distance from shore.

Bathymetry

In 2000, multiple riverbed transects were conducted to determine bottom profiles at all existing and alternate sites on the Egegik and Ugashik Rivers. These transects were measured during high slack tide using a boat-mounted depth sounder and a range finder. A marker was placed on shore to indicate the start of the first transect. As the boat maneuvered out from the marker, distance measurements were taken from the marker and recorded with a corresponding water depth. Reference points were created 100 m above and below the marker and more transects were completed until enough data points were recorded to map the bottom of the river. When the river bottom was irregular, more transects were needed to acquire an accurate picture of the bottom.

Gillnet Sampling

Existing Sites. Gillnets were drifted at all inriver test fishing sites to estimate sockeye salmon abundance in 2000. All rivers except the Igushik were fished in 2001. All gillnets were 45.7 m (150 ft or 25 fathoms) in length and 29 meshes deep. Monotwist web, hung with #50 twine and dyed Momoi shade #1 was used on all rivers. A stretched mesh size of 12.70 cm (5 in) was used on the Kvichak River, and 13.02 cm (5-1/8 in) was used on the Egegik, Igushik, and Ugashik Rivers. All drifts were made perpendicular and close to shore based on the assumption that sockeye salmon migrate parallel to, and near the riverbank. Drifts at all stations ended when the inshore end of the net drifted about 25 m offshore, or when it was no longer fishing efficiently. Two short drifts of less than 15 min duration were made at each station of each river beginning about 1.5 hours before every high slack tide to minimize currents carrying the gillnets offshore. When catches increased to the point where two drifts per station were difficult to process given time restraints, only one drift was made at each station until catches fell to a manageable level again.

Alternate Sites. In early 2000, a new boat and motor were purchased, along with three 13.02 cm (5-1/8 in) mesh gillnets. A two-person crew was hired in June and trained at the

Kvichak River by the existing test fish crew from 20-24 June. Once the new crew was trained, they traveled to the Egegik River and commenced fishing at alternate sites following the same procedures as at the existing sites. In 2000, test fishing was conducted at the alternate Egegik sites for a nine-day period and at the alternate Ugashik sites for a six-day period. In 2001, test fishing was conducted at the alternate Ugashik site concurrently with the existing site for a 19-day period.

Data Analyses

Mean fishing time (MT), in minutes, was calculated for each set as

$$MT = SI - FO + \frac{(FO - SO) + (FI - SI)}{2} \quad , \qquad (1)$$

where:

SO = time the gillnet first entered water,

FO = time the gillnet was fully deployed,

SI = time the gillnet retrieval began, and

FI = time the gillnet retrieval completed.

The CPUE value, C_j, or the number of sockeye salmon caught per 100 fathom hours, was calculated for set j as follows:

$$C_j = 6{,}000 \frac{N}{G \times MT} \quad , \qquad (2)$$

where:

N = number of sockeye salmon caught, and

G = gillnet length in fathoms.

The daily test fish index, I_i, for day i was calculated as the mean of individual CPUE values obtained from sets made the same day, or

$$I_i = \frac{\sum_{j=1}^{s} C_j}{S} \quad , \tag{3}$$

where:

S = number of sets made during day i (usually four sets per day).

Travel-time analysis was used to estimate daily escapement for the site comparison study. Travel-time estimates of spawning escapements were based on the number of days it took sockeye salmon to travel from test fish sites to counting tower sites. A range of travel-time estimates was calculated by matching daily test fish indices to daily tower counts. The number of sockeye salmon represented by each index point was calculated by dividing the most recent tower count by daily test fish indices lagged back in time by daily increments such that

$$FPI_d = \frac{\sum_{i=1+d}^{t} E_i}{\sum_{i=1}^{t-d} I_i} \quad , \tag{4}$$

where:

FPI_d = number of sockeye salmon represented by each test fishing index point based on a travel-time of d days,

E_i = number of sockeye salmon traveling past counting tower on day i, and

I_i = daily test fish index on day i, and

t = day of most recent escapement estimate.

We chose lag d that minimized the following sum of squares, SS, between the cumulative test fish indices and the tower counts where

$$SS = \sum_{j=1}^{t-d} (FPI_d \cdot \sum_{i=1}^{j} I_i - \sum_{i=1}^{j} E_{i+d})^2 \; . \tag{5}$$

Total spawning escapement was then estimated as

$$\hat{T}_{t+d} = FPI_d \sum_{i=1}^{t} I_i \quad , \tag{6}$$

where:

T_{t+d} = estimate of the cumulative number of sockeye salmon that will have passed counting tower on day $t+d$.

Three statistics were used to measure performance of the escapement estimator. Percent error (PE) was used to measure daily performance as

$$PE = 100 \ x \frac{T_{t+d} - \sum_{i=1}^{t+d} E_i}{\sum_{i=1}^{t+d} E_i} \ . \tag{7}$$

Mean percent error (MPE) was used to measure bias:

$$MPE = \frac{1}{n}\sum_{t=1}^{n}\left(100\, x \frac{T_{t+d} - \sum_{i=1}^{t+d} E_i}{\sum_{i=1}^{t+d} E_i} \right) \ , \tag{8}$$

where:

n = total number of days that escapement estimates based on test fishing were available.

Mean absolute percent error (MAPE) was used to measure overall accuracy because it treated under- and over-estimation errors similarly:

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left| \left(100\, x \frac{T_{t+d} - \sum_{i=1}^{t+d} E_i}{\sum_{i=1}^{t+d} E_i} \right) \right| \ . \tag{9}$$

The MPE and MAPE results from the existing and alternate sites were compared to see if the existing site location could be improved.

The estimates of inriver fish from the existing and alternate sites were compared to observed inriver fish and evaluated using both MAPE and MPE. The estimated inriver fish were calculated using the following equation:

$$E\hat{R}F_t = FPI_d \cdot \sum_{i=t-d+1}^{t} I_i \qquad (10)$$

where:

$E\hat{R}F_t$ = estimated river fish at time t

FPI_d = fish per index with lag d, and

I_i = test fish index at day i.

The observed inriver fish were calculated using the following equation:

$$ERF_t = \sum_{i=t+1}^{t+d} E_i \qquad (11)$$

where:

ERF_t = observed river fish for time t, and

E_i = observed escapement at tower for time i.

When calculating the estimated and observed inriver fish, the lag time from the travel time analysis was used and assumed to be correct.

Factors Which May Affect Test Fish Results

Fishing Time Relative To Tide Stage

A Unidata Starlog[1] data logger and depth probe were deployed at the Egegik (1-6 July) and Ugashik (9-16 July) test fish sites in 2000 and at the Ugashik (20 June-2 July) site in 2001. Water depth was recorded every minute in 0.08 m increments, and water temperature was recorded to the nearest 0.1°C. The logger began collecting data when 0.5 m of water was above the probe. The exact time of each high slack tide was determined for comparison to published times.

Seasonal Factors

Seasonal factors (e.g. river bottom bathymetry, water temperature, water turbidity, water discharge, crew experience, escapement abundance, escapement age composition and average length in the escapement) were evaluated using present and historical data sets to

[1] Use of a company's name does not constitute endorsement.

determine the significance they had on our forecasting model. Available data were plotted against the season ending test fishery FPI to assess their importance for predicting FPI. They were also plotted against MAPE to determine how they relate to the accuracy of the test fish estimates.

Gear Selectivity

Scales for aging, along with sex, length, and girth information were collected from approximately 40 fish per day from each test fish site in 2000 and 2001. Scales were collected from the "preferred area" for age data (INPFC 1963). Mid-eye to the fork of the tail measurements were measured with tree calipers, and girth measurements were measured with a flexible tape measure. Girth was measured at three different places: the posterior edge of the operculum, the anterior edge of the dorsal fin, and at the farthest posterior extent of the net mark, if one was visible.

To reduce costs and effort associated with the project, we elected to estimate selectivity curves using length and girth data collected from fish caught in our current mesh size nets instead of fishing multiple mesh sizes. Selectivity was estimated as the product of the following two probabilities, 1) the probability that a sockeye salmon of given length could push its head into a gill net as far as the operculum, and 2) the probability that the girth of a sockeye salmon was greater than the gillnet. A correction factor (effective mesh size) of 1.15 times the estimated mesh size was used to account for mesh stretch and fish flesh compression (e.g. a 12.70 cm (5 in) mesh gillnet is 254 mm in perimeter and will allow fish with maximum girth of 254 X 1.15 = 292 mm or less to pass through). The stretched mesh size used for comparisons started from 12.38 cm (4-7/8 in) and increased by 0.32 cm (1/8 in) increments to 13.98 cm (5-1/2 in). Separate selectivity curves were estimated for the Kvichak, Egegik, Ugashik, and Igushik Rivers in 2000 and for the Kvichak, Egegik, and Ugashik Rivers in 2001. The 2000 run size distributions were closer to the average than the 2001 runs; therefore, the selectivity curves generated from the 2000 runs were used to calculate probability of capture for all length classes of fish (400-670 mm; 5 mm increments) from 1990-2000. The methodology for estimating our selectivity curves incorporated the model developed by Kawamura (1972) and summarized by Hamley (1975).

Net efficiency is defined as:

$$\hat{E} = \sum_{i=1}^{n} P_i \, x \, PL_i \ , \qquad (12)$$

where:

$\hat{E}$ = estimated net efficiency

P_i = probability of capture from estimated selectivity for fish of length i, and

PL_i = the proportion of fish in length class i found in the escapement.

To evaluate the accuracy of the selectivity curves and the performance of each mesh size we use, we divided the proportion of all length classes of fish captured in the test fishery by the proportion of the same length classes captured at the tower site for years in which length information was collected at each project. We then averaged the yearly results. It should be noted that samples at the tower sites were captured with beach seine, which is considered to have less bias in size selectivity than gillnets used at the river test fish sites. We believe that age and size composition remains constant through time.

Analyses of Inseason Estimates

Historically, two methods have been used to estimate daily inriver abundance: (1) mean FPI value (FPI_a), and (2) travel-time (FPI_d) (Crawford et al. 2002). Method 1 is used at the start of each season before tower escapement data are available or in sufficient quantity that a meaningful relationship can be established with the test fish data (Method 2).

Pre-tower Estimates

Previously, mean FPI values were used to estimate the abundance of inriver fish at the beginning of each season, but in this report we explored alternatives. Mean FPI values used to estimate inriver fish abundance were calculated by taking the mean of final FPI values from previous seasons. The final FPI value from a single season is the FPI value recorded on the last day of test fishing. The years selected for the mean FPI value reflect recent trends in final FPI, recent trends in run strength, preseason forecasts of abundance, age structure, and in some cases exclude historical highs and lows. The mean FPI estimate of inriver fish abundance is the product of the mean FPI and the cumulative inriver test fish index. Mean FPI value estimates of inriver fish abundance were used until travel time analysis estimates proved more accurate.

In this study, we examined other options for deriving a pre-tower estimate of FPI. First, beginning in 1991, each year was assigned a value of FPI. Rather than use the end of season FPI value as previous studies have done, we chose to use an average of the first three values of FPI after "lock-in" (the point at which the travel time method commences each year) because we are most interested in FPI near the start of the run and in some years estimates of FPI change substantially throughout the run. Second, we chose independent variables that may relate to FPI and have time series going back to 1991, such as:

(a) Percent 2-ocean fish in the escapement,
(b) Average length in the escapement,
(c) Escapement numbers, and

(d) Water velocity (taken from each river's smolt project, which ends approximately one week prior to the start of the test fish projects).

All data sets were tested with and without log-transformations.

Additionally, we examined the usefulness of a five-year median, three- and five-year average, and univariate time series analysis of FPI. Similar to FPI, the independent variables were calculated based on data prior to lock-in. For example, the percent of 2-ocean fish in the escapement applies to age samples prior to the lock-in date each year. Third, simple linear regression models determined the significance of each independent variable on FPI. Lastly, model performance (accuracy) was evaluated based on mean absolute deviation (MAD) and MAPE for the previous three years.

FPI Estimates from Test Fish Data and Inseason Tower Data

We compared three methods for forecasting inseason escapement by modeling the relationship between test fish data and tower counts. Both daily and cumulative data from 2001 were used in the comparisons. The travel time model used in Bristol Bay test fisheries since the late 1970's (Gray 1999) was evaluated along with a maximum likelihood (MLE) approach and a regression model. The models were fit by comparing test fish indices to lagged escapement data. Escapement data were lagged to account for the travel time of sockeye salmon from the test fish site to the tower sites. Lags were chosen by determining which lag resulted in the best model fit. Ideally, knowledge about the stock and river system will help determine the best lag. Thus, travel times that appeared unrealistic based on results of past studies or produced unreasonable escapement estimates (e.g., less than observed escapement) were rejected even if they produced the best statistical fit to the data. All methods were examined for their ability to forecast escapement.

Travel Time Approach. The travel time approach has been used successfully to forecast the escapement at counting towers using inside test fish data for several Bristol Bay systems (Gray 1999). This method is described in equations 3-5. Results using both daily and cumulative escapement information were compared.

Maximum Likelihood Approach. The maximum likelihood approach has more desirable statistical properties than the travel time method, such as an asymptotically smaller variance. FPI was estimated by minimizing the sums of squares of the difference between the observed and predicted escapements using

$$SS = \sum_{i=1}^{t} (FPI \cdot I_i - E_{i+d})^2 \, . \qquad (13)$$

If the model errors are assumed to be normally distributed, minimizing the sums of squares will maximize the following equation, resulting in a MLE estimate of *FPI*.

$$L(FPI,\sigma^2 \mid E_{i+d}, I_i) = \prod_{i=1}^{n} \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{(E_{i+d}-FPI\cdot I_i)^2}{2\sigma^2}} , \tag{14}$$

where:

σ^2 = variance of E_i.

This method is equivalent to fitting a regression line with intercept equal to zero and *FPI* as the slope:

$$E_{i+d} = FPI \cdot I_i \ . \tag{15}$$

This model was fit with both daily and cumulative data.

Regression Approach. A linear regression model was fit to find the best linear relationship between the index and escapement. The regression equation fit was:

$$E_{i+d} = \alpha + \beta I_i \ , \tag{16}$$

where α and β were estimates of the intercept and slope. The assumptions of the error structure of the regression model were a normal distribution with constant variance. The regression model was fit with both daily and cumulative data.

Forecasting. An inseason forecasting scenario was used to compare the performance of the different methods. The forecasts for each day were generated using only the 'data to date'. Forecasts were generated for lags of 1, 2, and 3. For example, on day seven, a forecast with a one day lag used the six data points gathered to date, while a forecast with a 3-day lag could only use four data points. A minimum of four data points was needed before a forecast could be made. The forecasts were then compared to the observed escapement data with the lag that corresponds to the one used in the forecast. The forecasts were compared graphically using mean percent error and mean absolute percent error.

RESULTS AND DISCUSSION

Comparison of Alternate and Existing Sites

Alternate test fish sites, one on each side of the river, were chosen on the Egegik and Ugashik Rivers in 2000. These sites were located approximately 300 m above the existing Egegik test fish site and approximately 1.5 km above the existing Ugashik test fish site. Global Positioning System (GPS) coordinates of all test fish sites are in Table 1. Bathymetry charts were made at the existing Kvichak sites (Figure 2), at the existing Egegik sites (Figure 3), at the alternate Egegik site (Figure 4), at the existing Ugashik sites (Figure 5), and at the alternate Ugashik sites (Figure 6). It appears there are no obvious problems with bottom structure at any of the sites which may have affected test fishing results. Additionally, minimal signs of fish milling were reported at the sites.

Egegik 2000

In 2000, the existing Egegik test fish project operated from 14 June to 13 July (West et al. 2000). Test fishing was conducted at the alternate Egegik sites from 29 June to 6 July. A total of 70 drifts were made at the alternate sites capturing 549 fish. During this same time period, 72 drifts were made at the existing sites capturing 621 fish. For the period of 29 June to 6 July, the alternate sites produced a cumulative index of 1,844 (Table 2), while the existing sites produced an index of 3,009 (Table 3).

From 29 June to 6 July, only travel time analysis was used to estimate fish passage. Data from the existing site was used for the alternate site until fishing commenced at the alternate site. FPI values ranged from 81 to 99 at the existing site and from 90 to 103 at the alternate site (Tables 2 and 3). Daily estimates from the existing site ranged from 75% below to 663% above the actual escapement, while daily estimates from the alternate site ranged from 88% below to 399% above the actual escapement (Tables 2 and 3). Accuracy (MAPE) and bias (MPE) for the estimated abundances from the existing site were 120% and 86%, while they were 88% and 34% at the alternate site. Daily absolute errors between ERF values and actual tower counts are in Figure 7. Pearson correlation coefficients at various lags indicated very little difference in fit between the two sites.

Ugashik 2000

In 2000, the existing Ugashik test fish project operated from 20 June to 20 July (West et al. 2000). The alternate Ugashik sites were fished from 9 to 14 July. A total of 38 drifts were completed at the alternate sites capturing 395 sockeye salmon. During this same time period, 44 drifts were performed at the existing sites capturing 415 fish. For the time period 9 to 14 July, the alternate sites produced a cumulative index of 1,620 while the existing sites produced a cumulative index of 1,411. No additional comparisons were made between the existing and alternate sites in 2000 because only six days were fished at the alternate sites. Also, comparisons were made in 2001 when both sites fished concurrently almost the entire season.

Ugashik 2001

In 2001, the existing Ugashik test fish project operated from 24 June to 16 July and the alternate test fish sites were fished from 24 June to 14 July (Crawford et al. 2002). For comparisons, only information from days in which both sites were fished concurrently (24 June to 14 July) was used. A total of 164 drifts were performed at the existing sites capturing 1,922 sockeye salmon, while a total of 164 drifts were performed at the alternate sites capturing 1,851 fish. A total cumulative index of 25,294 was reached at the existing sites and a cumulative index of 24,144 was reached at the alternate sites (Tables 4 and 5).

The travel-time model "locked-in" on 4 July. From 4-14 July, FPI values ranged from 23 to 40 at the existing sites and from 23 to 39 at the alternate sites (Tables 4 and 5). Travel time abundance estimates from the existing sites ranged from 67% below to 261% greater than actual counts, while estimates from the alternate sites ranged from 51% below to 180% above the actual tower counts (Tables 4 and 5). Accuracy (MAPE) and bias (MPE) for the estimated abundances from the existing sites were 69% and 29%, while they were 51% and 22% at the alternate sites. Daily absolute errors between ERF values and actual tower counts are in Figure 8. As with the site comparisons at the Egegik River in 2000, the alternate sites performed slightly better, but not at a level to warrant moving the sites.

Factors Which May Affect Test Fish Results

Evaluation of Fishing Times Relative to Tide Stage

Egegik. Based on information gathered in 2000, high slack tide at the Egegik test fish site occurs about 30 min earlier than the published high slack tide at Nushagak Bay Clark's Point (NBCP) (Table 6). In 2000, the average time to complete 4 drifts was 56 min. The crew completed their drifts an average of 4 min before actual high slack tide. This suggests we remain with the current time of drifting 1.5 hours before published NBCP high slack tide.

To compensate for extremely high catch rates, the crew will move to a schedule of two drifts per tide until catch rates fall to a manageable rate again. The problem with this procedure is relying on only one drift per station. However, increasing the scheduled drift start time to include four drifts would be difficult. Much of the time the boat is still beached and water is still flowing downstream during the lower high tides (B. J. Russell, Alaska Department of Fish and Game, personal communication).

Ugashik. We currently drift 1.5 h before NBCP high slack tide with high slack tide water levels above 5.2 m, and 2 h before NBCP with high slack tide water levels 5.1 m and below. High slack tide at the Ugashik test fish site occurs about 45 min before the published high slack tide at NBCP (Tables 6 and 7). In 2000, the average time to complete 4 drifts was 63 min and in 2001 was 51 min. The crew finished their drifts an average of 13 min beyond high slack tide in 2000 and an average of 21 min beyond high slack tide in 2001. We also observed that tide level < 5 m would occur about 1 h before NBCP and any tide > 5 m tended to be about 30-45 min before NBCP. This suggests we add an additional 15 min to our present drift schedule.

Seasonal Factors

The original operational plan lists several factors that could be used to estimate FPI: bathymetry, water temperature, turbidity, river discharge, crew experience, run abundance, run composition and gear selectivity. It was our original intent to try to quantify these factors and implement them into the forecasting model; however, this proved to be difficult. The success of accounting for these factors depended upon having enough data and contrasting treatments among these variables in the data sets to derive a useful model. We put considerable effort into determining how these factors could be quantified and if correlations exist between them and the test fishery results. The main problem we encountered was isolating a single factor and finding a direct relationship with the test fish results. Gear selectivity was evaluated at a more intense level since there was a high proportion of 3-ocean fish in the 2000 and 2001 escapements, which likely affected the catchability of fish in the test fishery.

Bathymetry. River bottom profile was supposed to be plotted multiple times during the course of a test fish project to see if changes occur during the season that would ultimately affect fish behavior. We felt that bottom profile did not change during the small time frame of four weeks in which test fishing was conducted, and according to the current test fish crews, changed little annually. Thus, bottom profiles were only mapped once for comparison of existing and alternate sites (Figures 2-6).

Water Temperature. Water temperature has been collected at the river test fish sites since 1989. Kvichak River mean water temperature varied between 10.8°C in 1991 and 15.4°C in 1997 (Appendix A.1). Mean water temperature on the Egegik River varied from 9.8°C in 1999 to 14.7°C in 1997 (Appendix A.2). Ugashik River mean water temperature fell between 11.5°C in 1991 and 16.9°C in 1997 (Appendix A.3). We looked to see if water temperature had any affect on fish behavior, specifically on travel time from the test fish site to the escapement project upriver. When we plotted daily mean water temperature and daily FPI, we found no obvious trend between the two variables on any year at any of the sites.

Turbidity. Changes in water turbidity can affect the catchability of salmon while using gillnets. When waters become less turbid, net avoidance may occur. This appears irrelevant at the test fish sites where the water remains at a constant, high level of turbidity from mixing tidal currents; therefore, turbidity was never measured at any of the test fish sites.

River Discharge. Although no water velocity measurements were taken from the test fish sites, there are related water velocity measurements taken for smolt projects, located above the intertidal zone near the lake outlets. These smolt projects typically last one month and terminate about one week before the test fish projects begin (Crawford 2001). These water velocities showed a significant positive relationship with FPI values at Ugashik River ($p < 0.01$). For Kvichak and Egegik Rivers, a positive relationship between water velocity and FPI exists, but with the p-values (Kvichak $p = 0.223$ and Egegik $p = 0.213$), it could not be determined if the relationship observed was due to random chance (Figure 9). For the purpose of this study and generally in fisheries management, a p value of ≤ 0.20 is considered significant. These correlations suggest that water velocity does affect FPI, probably through fish swimming speeds. This would explain the strong correlation at Ugashik River since it has the widest range of water velocities.

Crew Experience. Crew experience was believed to affect test fish results. Experienced crews may catch a higher proportion of the fish passing by; however, crew experience proved too difficult to measure because an individuals experience is not only a function of how long they've worked on a particular project, but also how long they have worked on similar projects in other areas, and their previous experience with boating, setting nets, picking fish, etc.

Escapement. Abundance and age composition of the escapement was examined and compared to historical season ending FPI values and MAPE. Results were mixed among sites but one trend was clear: run abundance had a significant linear relationship (all p values < 0.05) with FPI (Figure 10). The test fish crews catch a small proportion of an escapement, and that proportion decreases as escapement increases, which causes FPI to increase. We use MAPE to measure accuracy between the predicted passage and actual tower counts. In comparing MAPE with escapement, the Kvichak showed a weak negative relationship and the Egegik showed a weak positive relationship (Figure 11). However, when we removed the 2001 data point, the relationship on the Kvichak was no longer significant. No significant relationship was observed for either Ugashik ($p > 0.90$) or Igushik ($p > 0.40$) Rivers. It should be noted that the interpretation of these findings is not straightforward.

It was believed that net saturation could occur with high passage rates, which would result in an underestimation of FPI and ultimately fish abundance. Comparing FPI with escapement, especially in years with high escapement, there was little evidence that net saturation actually occurs (Figure 10). The sampling procedures compensate for net saturation by allowing the crew to pull the net before they feel saturation may occur. Intentional shortening of the drifts during high passage rates has probably been reducing the effects of net saturation.

Age composition (% 2-ocean fish) showed a positive correlation ($p = 0.016$) with FPI at Kvichak River, and a weak negative correlation at Igushik River ($p = 0.118$). For Egegik and Ugashik Rivers, there was a positive relationship between % 2-ocean fish and FPI, but the relationships are not significant (Egegik $p = 0.226$ and Ugashik $p = 0.228$; Figure 12). This was expected because years with high abundance usually have a high proportion of 2-ocean fish, especially at the Kvichak River. It should be noted that on the Igushik River, the highest percentage of 2-ocean fish is < 60% and on the Kvichak, Egegik and Ugashik Rivers, the majority of 2-ocean runs are > 50%. Figure 13 shows a significant negative relationship between MAPE and % 2-ocean on the Kvichak ($p < 0.01$) and Ugashik Rivers ($p = 0.122$). However, when we removed the 2001 data point on both rivers, the relationship was no longer significant. No significant relationship was found on the Egegik ($p > 0.60$) and Igushik ($p > 0.60$) Rivers.

Average length of fish in the escapements was compared to FPI at all the sites (Figure 14). A significant negative relationship exists at Kvichak ($p = 0.013$), Egegik ($p = 0.030$) and Ugashik ($p = 0.064$), but no correlation was observed at Igushik River ($p > 0.70$). This agrees with the previous findings of % 2-ocean vs FPI. As the smaller 2-ocean fish increase in abundance, FPI increases. In comparing MAPE to average length in the escapement, a significant positive relationship was observed on the Kvichak ($p = 0.018$) and significant negative relationship on the Ugashik ($p = 0.050$; Figure 15). However, when we remove the 2001 data point from both rivers, the relationships were no longer significant. No correlation was observed at Igushik ($p = 0.275$) River or at Egegik ($p > 0.50$) River.

MAPE was compared to FPI at all sites (Figure 16). There was a weak correlation ($p = 0.136$) at the Kvichak River, but no correlation ($p > 0.50$) at the Egegik, Ugashik and Igushik Rivers.

Gear Selectivity

Kvichak. A total of 275 samples were collected from the Kvichak River in 2000, and the fish averaged 545 mm in length and 344 mm in dorsal girth (Table 8). A total of 395 samples were collected from the Kvichak River in 2001, and the fish averaged 580 mm in length and 368 mm in dorsal girth (Table 9). Age-1.3 was the most abundant age class in both 2000 and 2001. Both years experienced an unusually high proportion of 3-ocean fish, but since the 2000 run had a smaller proportion of 3-ocean fish, selectivity curves were created using length and girth from that year (Figure 17). Length and girth data used to estimate the selectivity curves for the Kvichak, Egegik, Ugashik, and Igushik Rivers are displayed in Figure 18. Estimated net efficiency of various mesh sizes for 1990-2001 are presented in Table 10. Using this information, it appears that we should increase our mesh sizes during years in which 3-ocean fish are proportionally more abundant. However, these probabilities do not compensate for fish getting caught in the net by entanglement around the head and mouth regions, which would skew the selectivity curves found in Figure 17 to the right (Quang and Geiger 2002).

When looking at the accuracy of the selectivity curve and the performance of capture for the current mesh size gillnet used (12.70 cm), results suggest that the current mesh does select for a majority of the run (Figure 19). However, it appears that smaller fish (< 480 mm) slip through the net and larger fish (> 605 mm) bounce off the net (lengths at which fish showed up in the escapement sampling at a higher proportion than fish captured with the gillnet). About 14% of the escapement samples were < 480 mm and about 6% were > 605 mm. This evidence suggests we may want to consider using a smaller mesh net, especially during years in which 2-ocean fish are abundant. However, the current mesh size gillnet will continue to be used because it selects for the majority of the length classes found in the escapement.

Egegik. A total of 638 samples were collected at the Egegik River in 2000 averaging 545 mm in length and 342 mm in dorsal girth (Table 11). A total of 400 samples were collected at the Egegik River in 2001 averaging 564 mm in length and 349 mm in dorsal girth (Table 12). Age-2.3 fish comprised the majority of the samples collected in 2000 and age-1.3 fish comprised the majority of the samples in 2001. Both years had an unusually high proportion of 3-ocean fish, but since the 2000 run had a smaller proportion of 3-ocean fish, selectivity curves were created using length and girth information from that year (Figure 20). For visual comparison, escapement length frequencies are also presented. Estimated net efficiency of various mesh sizes for the years 1990-2001 are in Table 13. Using this information, it would appear that we should increase our mesh sizes during years in which 3-ocean fish are proportionally more abundant. However, these probabilities do not compensate for fish getting caught in the net by entanglement around the head and mouth regions.

When looking at the accuracy of the selectivity curve and the performance of capture of the current mesh size gillnet used (13.02 cm), results suggest that the current mesh size performs better than the selectivity curves predicted (Figure 21). Furthermore, this information suggests a 13.02 cm (5-1/8 in) stretched mesh net is doing a good job of capturing fish that compose the majority of the escapement. Once again there is evidence of the smaller (< 485 mm) and larger (> 590 mm) fish in the escapement not being captured as well with gillnets. About 19% of the fish in the escapement sampling were < 485 mm and about 18% were > 590 mm. Since these numbers are similar, it appears our current mesh size is sufficient.

Ugashik. In 2000, 391 samples were collected at the Ugashik River averaging 559 mm in length and 350 mm in dorsal girth (Table 14). A total of 316 samples were collected at the Ugashik River in 2001 averaging 567 mm in length and 350 mm in dorsal girth (Table 15). Age-1.3 fish comprised the largest age class in both samples. Both years experienced an unusually high proportion of 3-ocean fish, but since the 2000 run had a smaller proportion of 3-ocean fish, selectivity curves were created using length and girth from that year (Figure 22). For visual comparison, escapement length frequencies are also presented. Estimated net efficiency of various mesh sizes for the years 1990-2001 are in Table 16. This information indicates we should increase our mesh sizes during years in which 3-ocean fish are proportionally more abundant; however, these probabilities do not compensate for fish getting caught in the net by entanglement around the head and mouth regions.

Figure 23 suggests that a 13.02 cm (5-1/8 in) mesh performs better than the selectivity curves predicted. As with the Kvichak and Egegik Rivers, there is evidence of the smaller (< 485 mm) and larger (> 590 mm) fish in the escapement not being captured as well with the current mesh net, but the net does select for the majority of the escapement. About 15% of the fish in the escapement sampling were < 485 mm and about 14% were > 590 mm. Since these numbers are similar, it appears we are using a suitable mesh size.

Igushik. A total of 238 samples were collected in 2000 from the Igushik River averaging 526 mm in length and 359 mm in dorsal girth (Table 17). Age-1.3 was the most abundant age class in the sample. The length and girth information became highly suspect when compared to the other rivers (Figure 18). The fish sampled seemed abnormally short and thick. Also, measurements were rounded to the nearest 10 mm, whereas other systems' measurements were to the nearest 1 mm. Selectivity curves created from this data were not accurate and are not presented.

Results varied annually, but when all years were combined, it became evident that a 13.02 mm (5-1/8 in) mesh is doing a fair job of catching the majority of the escapement (Figure 24). The gillnet appears to catch an equal proportion of the fish between 500 and 625 mm, but catches a smaller proportion of the fish > 625 mm. Fish > 625 mm composed 4% of the escapement during the years that were compared (1989, 1991, 1992, 1995, 1996). If the project were to start again, we may want to consider collecting length and girth information from gillnet captured fish to improve the data set.

Analyses of Inseason Estimates

Pre-Tower

An exploratory study showed that various factors relate to early season FPI values. These factors were then used to forecast FPI prior to the collection of tower escapement data. For the Kvichak River, significant ($\alpha = 0.20$) relationships occurred between FPI and age composition of the escapement (% 2-ocean) ($p = 0.005$) (Figure 25), average length of the escapement ($p = 0.036$) (Figure 26), and water velocity ($p = 0.105$) (Figure 27). Based on forecasting performance in recent years, the best two forecasting models use (1) age composition of the escapement and (2) a univariate time series model of FPI that incorporates an autoregressive parameter of lag 1.

For Egegik River, significant ($\alpha = 0.20$) relationships occurred between FPI and average length of the escapement ($p = 0.103$) (Figure 26) and escapement numbers ($p = 0.151$) (Figure 28). Based on forecasting performance in recent years, the best two forecasting models use (1) a univariate time series model of FPI that incorporates a moving average parameter of lag 2 and (2) escapement numbers.

For Ugashik River, significant ($\alpha = 0.20$) relationships occurred between FPI and age composition of the escapement (% 2-ocean) ($p = 0.024$) (Figure 25), average length of the escapement ($p = 0.007$) (Figure 26), and escapement numbers ($p = 0.062$; Figure 29). Based on forecasting performance in recent years, the best two forecasting models use (1) age composition of the escapement and (2) average length of the escapement.

FPI Estimates from Test Fish Data and Inseason Tower Data

In general, there is a positive relationship that could be modeled between tower escapements and daily test fish indices for both cumulative and daily data (Figures 30-35). The extremely good fit of the cumulative data indicates that it may forecast better than the daily data. However, the cumulative data is highly autocorrelated. Thus, methods that assume independence will greatly underestimate the variance, giving an appearance of highly significant models. When autocorrelation is taken into account using ARIMA models, these models use the differences between adjacent cumulative counts for the analysis. The differences in adjacent cumulative counts are the daily counts, supporting the idea that daily counts provide better estimates. Also, as the fishing season progresses, the precision of the FPI estimated with daily data improves, while the precision of the FPI from the cumulative data does not. We also looked at comparing daily data with hourly data and found that hourly data was highly variable in its ERF estimates and MAPE.

Of the different estimating methods, the MLE and the traditional travel time method produce very similar inseason forecasts, but the MLE method has more desirable statistical properties. The difference in performance between the two methods is not clear (Figures 30-35). Examination of the MPE and MAPE for forecasts one day ahead showed that the MLE performed better than the daily travel time method as well as the cumulative travel time model (Tables 18 and 19). In particular, the MLE has a smaller variance than the travel time method (Arnold 1990). The smaller variance was demonstrated by the smaller values for MPE and MAPE. In most cases, the regression did not forecast as well as the MLE or travel time method (Tables 18 and 19; Figures 30-35). This is probably because regression is based on a different model. Both the travel time and MLE methods assume that when the index is zero, the escapement is zero. The regression has more flexibility allowing for the escapement to be different from zero. This intercept allows for the different sampling methods to have different catchabilities, which is a possibility at low rates of escapement. Also, for both the MLE and regression, if the residuals do not have a constant variance, then adjustment to the analysis, such as taking the log of the dependent variable, need to be made. Overall, the MLE is a better method when the intercept is zero, and regression should provide a better estimate when the intercept is not zero. Inseason, we will continue to use the daily travel time method and compare results with the MLE method to forecast our inriver fish estimates.

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Table 1. Locations (GPS coordinates) of existing and alternate Bristol Bay sockeye salmon test fishing stations.

River	Test Fishing Stations	River Bank	GPS Coordinates[1]
Kvichak River	1	West	N 59° 01.375', W 156° 52.565'
	2	East	N 59° 03.402', W 156° 51.110'
Egegik River	1	South	N 58° 11.993', W 157° 11.087'
	2	North	N 58° 12.150', W 157° 10.465'
Egegik River [2]	1	North	N 58° 11.972', W 157° 09.868'
	2	South	N 58° 11.018', W 157° 09.148'
Ugashik River	1	East	N 57° 33.244', W 157° 25.365'
	2	West	N 57° 33.423', W 157° 25.554'
Ugashik River [2]	1	East	N 57° 33.575', W 157° 22.957'
	2	West	N 57° 34.258', W 157° 22.188'
Igushik River	1	South	N 58° 49.51', W 159° 02.36'
	2	North	N 58° 49.48', W 159° 02.36'

[1] GPS coordinates are generally considered to be accurate within 17 m.
[2] Alternate sites

Table 2. Sockeye salmon inriver test fishing data summary and comparison to tower counts, existing site, Egegik River, 2000.

	Test Fishing				Model Estimates Travel Time Analysis			Observation Tower			
Date	Fishing Time(min)	Catch (no)	Daily Index	Cumulative Index	Lag	FPI	Estimated River Fish [a]	Date	Daily Escapement	Cumulative Escapement	Daily Percent Error of Test Fishing Estimate
6/23										[b]	
6/24									48,984	91,734	
6/25									94,056	185,790	
6/26									159,468	345,258	
6/27									201,906	547,164	
6/28									45,234	592,398	
6/29	71.7	73	231	231	3	90	40,881	6/29	18,210	610,608	0
6/30	71.1	66	220	451	3	90	48,868	6/30	7,758	618,366	-15
7/1	69.6	17	57	508	3	92	46,560	7/1	23,580	641,946	-16
7/2	67.6	60	218	726	2	87	24,036	7/2	9,660	651,606	-48
7/3	72.9	4	14	740	3	91	26,188	7/3	23,940	675,546	-75
7/4	53.0	300	1,912	2,652	3	93	199,056	7/4	21,894	697,440	124
7/5	66.4	86	302	2,954	3	99	219,967	7/5	65,730	763,170	663
7/6	66.1	15	55	3,009	2	81	28,831	7/6	16,638	779,808	136
7/7								7/7	6,360	786,168	
7/8								7/8	5,832	792,000	
6/29 - 7/6					Mean Percent Error (MPE)						86
					Mean Absolute Percent Error (MAPE)						120

[a] Estimated river fish is the estimate of fish that have entered the river but have not passed the counting tower, based on the least sum of squares run timing model.

[b] Tower became operational on 6/19 and cumulative escapement through 6/23 was 42,750.

Table 3. Sockeye salmon inriver test fishing data summary and comparison to tower counts, alternate site, Egegik River, 2000.

	Test Fishing				Model Estimates Travel Time Analysis			Observation Tower			
Date	Fishing Time(min)	Catch (no)	Daily Index	Cumulative Index	Lag	FPI	Estimated River Fish [a]	Date	Daily Escapement	Cumulative Escapement	Daily Percent Error of Test Fishing Estimate
6/23										[b]	
6/24									48,984	91,734	
6/25									94,056	185,790	
6/26									159,468	345,258	
6/27									201,906	547,164	
6/28									45,234	592,398	
6/29	52.7	27	112	112	3	90	28,401	6/29	18,210	610,608	-31
6/30	70.7	44	128	240	3	90	29,964	6/30	7,758	618,366	-48
7/1	66.8	15	52	292	3	92	26,756	7/1	23,580	641,946	-52
7/2	64.5	22	84	376	3	92	34,276	7/2	9,660	651,606	-25
7/3	64.6	0	0	376	3	93	12,807	7/3	23,940	675,546	-88
7/4	75.6	370	1,186	1,562	3	96	121,560	7/4	21,894	697,440	37
7/5	54.4	49	203	1,765	3	103	143,779	7/5	65,730	763,170	399
7/6	66.3	22	79	1,844	2	91	25,748	7/6	16,638	779,808	111
7/7								7/7	6,360	786,168	
7/8								7/8	5,832	792,000	
6/29 - 7/6					Mean Percent Error (MPE)						34
					Mean Absolute Percent Error (MAPE)						88

[a] Estimated river fish is the estimate of fish that have entered the river but have not passed the counting tower, based on the least sum of squares run timing model.

[b] Tower became operational on 6/19 and cumulative escapement through 6/23 was 42,750.

Table 4. Sockeye salmon inriver test fishing data summary and comparison to tower counts, existing site, Ugashik River, 2001.

	Test Fishing				Model Estimates Travel Time Analysis			Observation Tower			
Date	Fishing Time(min)	Catch (no)	Daily Index	Cumulative Index	Lag	FPI	Estimated River Fish [a]	Date	Daily Escapement	Cumulative Escapement	Daily Percent Error of Test Fishing Estimate
6/24	61.8	21	81	81						[b]	
6/25	64.6	14	52	133						[b]	
6/26	63.1	16	60	193						[b]	
6/27	69.0	16	57	250						[b]	
6/28	64.0	39	147	397						[b]	
6/29	65.7	42	154	551				6/29	2,934	2,934	
6/30	67.2	61	218	769				6/30	7,104	10,038	
7/1	33.9	30	214	983				7/1	5,862	15,900	
7/2	66.8	47	169	1,152				7/2	3,876	19,776	
7/3	66.9	36	129	1,281				7/3	5,358	25,134	
7/4	66.9	66	236	1,517	3	24	8,945	7/4	3,066	28,200	-67
7/5	53.2	89	459	1,976	2	23	16,055	7/5	1,386	29,586	-38
7/6	13.7	197	3,378	5,354	2	23	86,906	7/6	4,782	34,368	-10
7/7	11.8	235	4,651	10,005	2	28	226,190	7/7	21,306	55,674	23
7/8	14.8	219	3,861	13,866	2	24	208,212	7/8	75,300	130,974	-18
7/9	16.1	208	3,207	17,073	2	24	168,822	7/9	108,018	238,992	-45
7/10	14.6	185	3,037	20,110	2	28	172,761	7/10	144,642	383,634	-42
7/11	16.6	150	2,349	22,459	3	39	337,423	7/11	160,836	544,470	49
7/12	17.4	136	1,874	24,333	3	40	290,165	7/12	137,880	682,350	179
7/13	26.6	85	821	25,154	3	37	186,275	7/13	60,390	742,740	261
7/14	51.8	30	140	25,294	2	32	30,425	7/14	27,624	770,364	27
7/15									16,122	786,486	
7/16									7,848	794,334	
7/4 - 7/14					Mean Percent Error (MPE)						29
					Mean Absolute Percent Error (MAPE)						69

[a] Estimated river fish is the estimate of fish that have entered the river but have not passed the counting tower, based on the least sum of squares run timing model.

[b] Observation towers not in operation.

Table 5. Sockeye salmon inriver test fishing data summary and comparison to tower counts, alternate site, Ugashik River, 2001.

	Test Fishing				Model Estimates Travel Time Analysis			Observation Tower			
Date	Fishing Time(min)	Catch (no)	Daily Index	Cumulative Index	Lag	FPI	Estimated River Fish [a]	Date	Daily Escapement	Cumulative Escapement	Daily Percent Error of Test Fishing Estimate
6/24	68.0	25	87	87						[b]	
6/25	67.5	23	81	168						[b]	
6/26	67.1	10	36	204						[b]	
6/27	67.5	19	68	272						[b]	
6/28	64.8	29	112	384						[b]	
6/29	67.4	29	103	487				6/29	2,934	2,934	
6/30	63.5	55	207	694				6/30	7,104	10,038	
7/1	33.8	36	255	949				7/1	5,862	15,900	
7/2	66.0	40	143	1,092				7/2	3,876	19,776	
7/3	65.6	42	156	1,248				7/3	5,358	25,134	
7/4	63.8	40	153	1,401	2	26	7,998	7/4	3,066	28,200	30
7/5	57.6	81	390	1,791	2	24	12,881	7/5	1,386	29,586	-51
7/6	19.4	271	3,789	5,580	2	25	102,488	7/6	4,782	34,368	6
7/7	14.2	245	4,250	9,830	2	31	249,848	7/7	21,306	55,674	36
7/8	13.8	235	4,135	13,965	2	23	196,786	7/8	75,300	130,974	-22
7/9	13.2	211	3,792	17,757	2	24	192,713	7/9	108,018	238,992	-37
7/10	14.5	143	2,353	20,110	2	27	168,798	7/10	144,642	383,634	-43
7/11	15.5	129	2,033	22,143	3	39	318,815	7/11	160,836	544,470	41
7/12	21.3	110	1,334	23,477	3	38	219,781	7/12	137,880	682,350	111
7/13	25.2	57	539	24,016	3	37	144,267	7/13	60,390	742,740	180
7/14	37.0	21	128	24,144	2	33	21,879	7/14	27,624	770,364	-9
7/15								7/15	16,122	786,486	
7/16								7/16	7,848	794,334	
7/4 - 7/14					Mean Percent Error (MPE)						22
					Mean Absolute Percent Error (MAPE)						51

[a] Estimated river fish is the estimate of fish that have entered the river but have not passed the counting tower, based on the least sum of squares run timing model.

[b] Observation towers not in operation.

Table 6. Comparison between high slack tides at Egegik and Ugashik test fish sites to published Nushagak Bay (Clark's Point) high slack tides, 2000.

	Test Fish Crew					Tide Data Logger					Published NBCP [a]			
Date	Drift set [b]	Start	Stop	Total Time	Catch	High Flood	High Ebb	High Slack	Depth (m) (at probe)	Water Temp (°C)	Time	Water Level (m)	Time Differential Actual vs Pub.	Time Differential Actual vs. Crew
								Egegik						
6/30	2	01:00	02:20	01:20	11						2:30	6.2		
6/30	3	12:13	13:06	00:53	33						13:45	5.2		
7/01	4	01:56	02:45	00:49	5	02:47	03:09	02:58	1.9	10.4	03:26	6.6	00:28	00:13
7/01	5	13:16	14:00	00:44	10						14:41	5.2		
7/02	6	02:59	03:46	00:47	16	03:48	03:53	03:50	2.1	10.2	04:22	6.9	00:31	00:04
7/02	7	14:10	14:58	00:48	6						15:41	5.1		
7/03	8	03:51	04:36	00:45	0	04:26	04:59	04:42	2.2	10.9	05:17	7.1	00:34	00:06
7/03	9	15:15	16:00	00:45	0						16:44	5.1		
7/04	10	04:45	05:51	01:06	66	05:29	05:33	05:31	2.3	10.9	06:11	7.3	00:40	(00:20)
7/04	11	16:17	18:24	02:07	304						17:49	5.2		
7/05	12	05:32	06:12	00:40	12	06:09	06:43	06:26	2.4	10.2	07:04	7.2	00:38	00:14
7/05	13	17:28	18:12	00:44	37	18:16	18:37	18:26	1.1	12.1	18:57	5.1	00:30	00:14
7/06	14	06:30	07:19	00:49	10	07:03	07:40	07:21	2.4	10.9	07:56	7.1	00:34	00:02
7/06	15	18:31	19:19	00:48	12									
Average				00:56	42					10.8			00:33	00:04
								Ugashik						
7/09						22:35	23:19	22:57	2.3	13.5	23:26	5.5	00:29	
7/10	1	10:08	11:19	01:11	37	10:19	10:58	10:38	2.5	13.0	11:17	5.9	00:38	(00:41)
7/10	2	23:03	00:01	00:58	26	23:42	00:16	23:59	2.4	14.2				(00:02)
7/11											00:29	5.7	00:30	
7/11	3	10:58	11:50	00:52	20	11:02	11:43	11:22	2.2	13.5	12:06	5.5	00:43	(00:28)
7/12	4	23:57	01:07	01:10	51	00:44	01:11	00:57	2.4	14.6	01:28	5.8	00:30	(00:10)
7/12	5	11:03	12:08	01:05	52	11:43	12:25	12:04	2.0	14.9	12:53	5.2	00:49	(00:04)
7/13	6	00:45	02:03	01:18	36	01:25	02:15	01:50	2.5	15.6	02:24	5.9	00:34	(00:13)
7/13	7	12:03	12:58	00:55	34	12:22	13:09	12:45	1.7	15.6	13:39	4.8	00:53	(00:13)
7/14	8	02:02	03:14	01:12	52	02:17	03:12	02:44	2.5	15.8	03:16	5.9	00:31	(00:30)
7/14	9	12:32	13:26	00:54	82	13:03	13:48	13:25	1.5	16.1	14:24	4.5	00:58	(00:01)
7/15						03:11	03:51	03:31	2.5	15.6	04:03	5.9	00:32	
7/15						13:19	14:25	13:52	1.3	14.9	15:08	4.3	01:16	
7/16						03:50	04:35	04:12	2.6	15.3	04:47	5.9	00:34	
7/16						14:51	14:57	14:54	1.3	14.6	15:51	4.1	00:57	
Average				01:03	47					14.8			00:42	(00:13)

[a] Published Nushagak Bay (Clarks Point) tides were taken from the TIDE.1 software application distributed by Micronautics, Inc.

[b] Four drifts per drift set.

Table 7. Comparison between high slack tides at Ugashik test fish site to published Nushagak Bay (Clark's Point) high slack tides, 2001.

	Test Fish Crew					Tide Data Logger					Published NBCP [a]				
Date	Drift set [b]	Start	Stop	Total Time	Catch	High Flood	High Ebb	High Slack	Depth (m) (at probe)	Water Temp (°C)	Time	Water Level (ft)	Water Level (m)	Time Differential Actual vs Pub.	Time Differential Actual vs. Crew
6/20						02:25	03:10	02:47	1.7	15.6	03:14	19.5	5.9	00:26	
6/20	1	13:10	14:02	00:52	11	12:50	13:39	13:14	0.9	14.4	14:15	15.3	4.7	01:00	(00:48)
6/21						03:14	03:47	03:30	1.9	13.7	04:04	20.6	6.3	00:33	
6/21	2	13:45	14:42	00:57	14	13:13	14:14	13:43	0.7	13.5	15:05	15.1	4.6	01:21	(00:59)
6/22	3	03:30	04:20	00:50	17	04:20	04:25	04:22	2.0	14.6	04:53	21.6	6.6	00:30	00:02
6/22	4	14:41	15:44	01:03	37	14:07	15:11	14:39	0.7	15.1	15:59	15.0	4.6	01:20	(01:05)
6/23	5	04:25	05:25	01:00	36	04:42	05:29	05:05	2.2	15.1	05:43	22.4	6.8	00:37	(00:20)
6/23	6	15:40	16:28	00:48	27	15:19	16:15	15:47	0.8	15.1	16:57	15.1	4.6	01:10	(00:41)
6/24	7	05:10	06:04	00:54	10	05:29	06:22	05:55	2.3	14.9	06:33	22.9	7.0	00:37	(00:09)
6/24	8	17:30	18:18	00:48	15	16:49	17:03	16:56	0.9	15.1	18:00	15.2	4.6	01:04	(01:22)
6/25	9	06:02	06:55	00:53	4	06:16	07:08	06:42	2.4	14.4	07:22	23.2	7.1	00:40	(00:13)
6/25	10	17:30	18:21	00:51	19	18:19		18:19	0.9	13.9	19:05	15.6	4.8	00:46	(00:02)
6/26	11	06:52	07:35	00:43	1	07:25	07:30	07:27	2.4	13.3	08:12	23.1	7.0	00:44	(00:08)
6/26	12	18:50	19:40	00:50	8	19:03	19:48	19:25	1.0	12.4	20:13	16.0	4.9	00:47	(00:15)
6/27	13	07:40	08:25	00:45	6	07:52	08:40	08:16	2.3	12.4	09:01	22.7	6.9	00:45	(00:14)
6/27	14	20:02	20:44	00:42	13	20:41	20:45	20:43	1.3	13.5	21:22	16.7	5.1	00:39	(00:01)
6/28	15	08:30	09:20	00:50	15	08:55	09:16	09:05	2.3	13.0	09:51	22.1	6.7	00:45	(00:15)
6/28	16	21:15	22:01	00:46	14	21:37	22:16	21:56	1.3	14.6	22:30	17.5	5.3	00:33	(00:05)
6/29	17	09:15	10:05	00:50	13	09:35	10:14	09:54	2.2	14.2	10:40	21.1	6.4	00:45	(00:11)
6/29	18	22:09	23:00	00:51	16	23:02		23:02	1.5	14.4	23:38	18.3	5.6	00:36	00:02
6/30	19	10:12	11:10	00:58	31	10:40	11:02	10:51	1.9	13.9	11:31	20.0	6.1	00:40	(00:19)
7/01	20	23:26	00:19	00:53	24	00:06	00:14	00:10	1.7	13.9	00:44	19.2	5.9	00:34	(00:09)
7/01	21	11:04	12:06	01:02	36	11:23	11:40	11:31	1.7	13.3	12:21	18.8	5.7	00:49	(00:35)
7/02	22	00:16	01:10	00:54	28	00:47	01:34	01:10	1.7	13.3	01:47	20.0	6.1	00:36	00:00
7/02	23	11:55	12:39	00:44	12	12:00	12:43	12:21	1.3	13.0	13:12	17.6	5.4	00:50	(00:18)
Average				00:51	18					14.0				00:46	(00:21)

[a] Published Nushagak Bay (Clarks Point) tides were taken from the TIDE.1 software application distributed by Micronautics, Inc.

[b] Four drifts per drift set.

Table 8. Length and girth measurements (mm) from sockeye salmon sampled at Kvichak River test fish site, 2000.

	Age Group					
	1.2	1.3	2.2	2.3	Unaged	Total
Mean Length	508	569	518	557	553	545
Mode	505	560	493	545	543	560
SE Length	3.1	2.5	3.7	7.5	5.4	2.3
Sample Size	56	112	44	17	46	275
Mean Dorsal Girth	319	360	325	352	350	344
Mode	340	350	300	340	340	340
SE Dorsal Girth	3.1	2.5	3.4	7.7	4.9	1.9
Sample Size	56	112	44	17	46	275
Mean Operculum Girth	283	320	291	308	315	306
Mode	295	300	300	320	300	300
SE Operculum Girth	2.9	2.5	3.0	7.4	4.7	1.8
Sample Size	56	112	44	17	46	275
Mean Net Mark Girth	292	292	292	295	292	292
Mode	290	290	290	290	290	290
SE Netmark Girth	1.2	0.8	1.0	3.0	1.6	0.5
Sample Size	56	96	43	16	38	249

Table 9. Length and girth measurements (mm) from sockeye salmon sampled at Kvichak River test fish site, 2001.

	Age Group						
	1.2	1.3	1.4	2.2	2.3	Unaged	Total
Mean Length	522	582	570	518	588	580	580
Mode		580				573	580
SE Length	7.1	1.3		11.0	5.7	4.6	1.4
Sample Size	11	318	1	3	13	49	395
Mean Dorsal Girth	325	371	380	317	370	366	368
Mode	315	360			360	360	360
SE Dorsal Girth	4.4	1.3		6.0	5.6	3.6	1.3
Sample Size	11	318	1	3	13	49	395
Mean Operculum Girth	292	330	317	287	331	329	329
Mode	310	320			355	320	320
SE Operculum Girth	4.3	1.3		4.4	6.9	4.0	1.3
Sample Size	11	318	1	3	13	49	395
Mean Net Mark Girth	300	307	317	309	307	305	307
Mode	305	310			310	300	310
SE Netmark Girth	4.8	0.8		4.6	3.8	1.9	0.7
Sample Size	11	297	1	3	11	42	365

Table 10. Estimated net efficiency for sockeye salmon that returned to Kvichak River, 1990-2001.

	Age Composition		Mesh Size in cm						
Year	% 2 ocean	% 3 ocean	12.06	12.38	12.70	13.02	13.34	13.66	13.98
1990	90.7	9.2	0.399	0.433	0.438	0.421	0.387	0.335	0.284
1991	77.5	21.7	0.323	0.377	0.405	0.412	0.401	0.371	0.336
1992	76.5	22.9	0.312	0.370	0.405	0.421	0.418	0.395	0.361
1993	66.9	30.0	0.153	0.206	0.254	0.300	0.339	0.371	0.386
1994	94.1	4.9	0.408	0.454	0.466	0.451	0.414	0.353	0.294
1995	87.3	12.7	0.319	0.404	0.459	0.487	0.484	0.446	0.392
1996	40.0	59.8	0.118	0.167	0.215	0.262	0.307	0.353	0.387
1997	79.3	20.1	0.191	0.249	0.299	0.342	0.375	0.396	0.398
1998	77.6	20.2	0.291	0.359	0.406	0.433	0.439	0.419	0.383
1999	90.4	9.5	0.327	0.392	0.432	0.450	0.446	0.415	0.371
2000	36.9	63.1	0.115	0.163	0.211	0.260	0.311	0.366	0.408
2001	10.3	89.3	0.049	0.070	0.094	0.122	0.158	0.175	0.225

Depicts the net with the highest estimated efficiency

Table 11. Length and girth measurements (mm) from sockeye salmon sampled at Egegik River test fish site, 2000.

	Age Group						
	1.2	1.3	2.1	2.2	2.3	Unaged	Total
Mean Length	490	568	360	511	563	550	545
Mode	520	570		510	554	582	570
SE Length	5.9	2.2		2.5	2.2	4.9	1.7
Sample Size	45	167	1	151	206	68	638
Mean Dorsal Girth	302	361	211	313	355	345	342
Mode	320	343		300	369	338	338
SE Dorsal Girth	4.8	2.1		2.4	1.9	4.3	1.4
Sample Size	45	167	1	151	206	68	638
Mean Operculum Girth	263	310	172	272	306	299	295
Mode	293	310		272	290	286	320
SE Operculum Girth	4.2	2.2		2.1	2.0	3.9	1.3
Sample Size	45	167	1	151	206	68	638
Mean Net Mark Girth	284	311	207	295	306	298	302
Mode	295	320		303	308	310	302
SE Netmark Girth	4.4	1.9		1.8	1.6	4.0	1.0
Sample Size	45	161	1	149	195	65	616

Table 12. Length and girth measurements (mm) from sockeye salmon sampled at Egegik River test fish site, 2001.

	Age Group									
	1.2	1.3	1.4	1.5	2.2	2.3	2.4	3.3	Unaged	Total
Mean Length	514	569	578	556	522	573	599	603	558	564
Mode		577			537	577			543	577
SE Length		1.8	5.5		4.9	2.3			4.7	1.6
Sample Size	1	154	2	1	50	145	1	1	45	400
Mean Dorsal Girth	314	349	352	326	317	359	343	351	351	349
Mode		338			300	354			357	338
SE Dorsal Girth		2.1	10.0		3.3	2.2			4.0	1.4
Sample Size	1	154	2	1	50	144	1	1	45	399
Mean Operculum Girth	268	306	306	289	278	312	319	305	302	304
Mode		292			297	293			296	292
SE Operculum Girth		2.0	13.5		2.7	2.2			4.5	1.3
Sample Size	1	154	2	1	50	145	1	1	45	400
Mean Net Mark Girth	287	306	321	326	296	311	294	276	300	306
Mode		316			311	326			295	314
SE Netmark Girth		2.3	2.0		2.8	2.1			5.3	1.4
Sample Size	1	153	2	1	50	145	1	1	45	399

Table 13. Estimated net efficiency for sockeye salmon that returned to Egegik River, 1990-2001.

	Age Composition		Mesh Size in cm					
Year	% 2-Ocean	% 3-Ocean	12.38	12.70	13.02	13.34	13.66	13.98
1990	69.2	30.3	$\boxed{0.406}$	0.390	0.363	0.328	0.298	0.271
1991	56.5	41.3	0.376	0.402	0.418	$\boxed{0.422}$	0.416	0.401
1992	63.3	33.9	0.410	$\boxed{0.415}$	0.407	0.387	0.362	0.335
1993	42.4	54.5	0.297	0.340	0.378	0.414	0.436	$\boxed{0.450}$
1994	70.5	25.8	$\boxed{0.413}$	0.406	0.386	0.353	0.322	0.293
1995	76.0	22.4	0.401	0.429	$\boxed{0.441}$	0.438	0.423	0.399
1996	36.9	58.4	0.240	0.285	0.330	0.378	0.416	$\boxed{0.447}$
1997	68.7	27.6	0.383	$\boxed{0.394}$	0.392	0.376	0.357	0.335
1998	34.4	59.1	0.289	0.333	0.375	0.417	0.445	$\boxed{0.461}$
1999	84.3	15.5	0.461	$\boxed{0.474}$	0.467	0.437	0.397	0.349
2000	33.3	66.3	0.243	0.290	0.341	0.401	0.449	$\boxed{0.489}$
2001	16.0	81.2	0.156	0.210	0.273	0.345	0.391	$\boxed{0.461}$

$\boxed{}$ Depicts the net with the highest estimated efficiency

Table 14. Length and girth measurements (mm) from sockeye salmon sampled at Ugashik River test fish site, 2000.

	Age Group					
	1.2	1.3	1.4	2.3	Unaged	Total
Mean Length	513	573	600	568	557	559
Mode	540	581		600	555	581
SE Length	4.0	2.2		5.6	4.7	2.0
Sample Size	45	238	1	17	66	391
Mean Dorsal Girth	317	360	350	348	350	350
Mode	330	355		330	330	330
SE Dorsal Girth	3.9	2.0		5.6	3.7	1.7
Sample Size	45	238	1	17	66	391
Mean Operculum Girth	276	317	315	306	309	307
Mode	252	345		280	320	295
SE Operculum Girth	3.6	2.0		5.9	3.5	1.7
Sample Size	45	238	1	17	66	391
Mean Net Mark Girth	293	301	278	312	303	301
Mode	305	315		312	335	305
SE Netmark Girth	3.6	2.2		4.5	3.8	1.6
Sample Size	44	215	1	14	59	357

Table 15. Length and girth measurements (mm) from sockeye salmon sampled at Ugashik River test fish site, 2001.

	Age Group								
	1.2	1.3	1.4	2.1	2.2	2.3	2.4	Unaged	Total
Mean Length	511	576	570	392	519	573	601	577	567
Mode	525	590				561		622	590
SE Length	3.8	1.9	14.2		18.4	7.8		5.9	2.1
Sample Size	41	210	9	1	3	16	1	35	316
Mean Dorsal Girth	318	355	346	233	314	364	402	360	350
Mode	320	340	350			370		360	340
SE Dorsal Girth	3.3	1.9	8.5		13.3	5.9		5.7	1.7
Sample Size	41	210	9	1	3	16	1	35	316
Mean Operculum Girth	285	320	310	215	278	327	380	325	315
Mode	300	300	290			310		332	300
SE Operculum Girth	2.9	1.8	9.5		12.4	6.2		5.6	1.7
Sample Size	41	210	9	1	3	16	1	35	316
Mean Net Mark Girth	290	307	314	230	303	320		302	305
Mode	310	320	300			330		320	310
SE Netmark Girth	4.4	1.7	4.1		8.8	7.4		5.6	1.6
Sample Size	40	180	8	1	3	16	0	28	276

Table 16. Estimated net efficiency for sockeye salmon that returned to Ugashik River, 1990-2001.

	Age Composition		Mesh Size in cm					
Year	% 2 ocean	% 3 ocean	12.38	12.70	13.02	13.34	13.66	13.98
1990	60.4	39.4	0.350	0.362	**0.363**	0.357	0.345	0.333
1991	56.6	42.9	0.387	0.411	**0.421**	0.416	0.398	0.374
1992	48.1	49.9	0.321	0.353	0.377	0.395	**0.405**	0.405
1993	47.1	51.5	0.264	0.313	0.358	0.396	0.428	**0.444**
1994	78.9	19.2	**0.475**	0.462	0.426	0.376	0.314	0.262
1995	79.6	20.1	0.419	0.459	**0.479**	0.477	0.451	0.413
1996	15.8	83.3	0.143	0.182	0.230	0.285	0.354	**0.413**
1997	64.6	32.4	0.358	0.371	**0.374**	0.367	0.351	0.334
1998	45.6	51.1	0.295	0.332	0.366	0.394	0.415	**0.421**
1999	88.6	10.9	0.474	0.514	**0.529**	0.517	0.473	0.416
2000	23.9	75.9	0.182	0.223	0.270	0.321	0.380	**0.428**
2001	18.8	80.6	0.128	0.158	0.194	0.236	0.351	**0.402**

Depicts the net with the highest estimated efficiency

Table 17. Length and girth measurements (mm) from sockeye salmon sampled at Igushik River test fish site, 2000.

	Age Group					
	1.2	1.3	2.2	2.3	Unaged	Total
Mean Length	462	530	530	523	521	526
Mode	460	530		540	530	530
SE Length	6.0	2.7		9.6	5.2	2.1
Sample Size	9	185	1	6	37	238
Mean Dorsal Girth	307	361	340	350	362	359
Mode	310	350		340	340	340
SE Dorsal Girth	4.4	2.1		11.6	4.8	2.0
Sample Size	9	185	1	6	37	238
Mean Operculum Girth	270	312	300	305	315	310
Mode	270	300			290	300
SE Operculum Girth	3.3	2.0		7.6	4.6	1.8
Sample Size	9	185	1	6	37	238
Mean Net Mark Girth	300	303	300	303	309	304
Mode	300	300		310	310	300
SE Netmark Girth	3.3	1.6		7.2	5.3	1.5
Sample Size	9	152	1	6	29	197

Table 18. Mean percent error (MPE) and mean absolute percent error percent (MAPE) for forecasts one day ahead for lags of one, two and three days at Kvichak, Egegik and Ugashik Rivers using daily escapement information, 2001.

	Lag	Method	Mean Percent Error	Mean Absolute Percent Error
Kvichak River	1	Travel Time	20	52
		MLE	24	50
		Regression	-19	77
	2	Travel Time	-30	78
		MLE	-22	77
		Regression	-53	102
	3	Travel Time	-62	95
		MLE	-41	79
		Regression	-83	120
Egegik River	1	Travel Time	-56	96
		MLE	-27	77
		Regression	-182	232
	2	Travel Time	-105	133
		MLE	-90	122
		Regression	-146	179
	3	Travel Time	-192	225
		MLE	-161	197
		Regression	-267	302
Ugashik River	1	Travel Time	-21	82
		MLE	-12	80
		Regression	8	61
	2	Travel Time	-28	56
		MLE	-23	53
		Regression	-28	62
	3	Travel Time	-102	127
		MLE	-84	116
		Regression	-95	127

Table 19. Mean percent error (MPE) and mean absolute percent error percent (MAPE) for forecasts one day ahead for lags of one, two and three days at Kvichak, Egegik and Ugashik Rivers using cumulative escapement information, 2001.

	Lag	Method	Mean Percent Error	Mean Absolute Percent Error
Kvichak River	1	Travel Time	194	194
		MLE	194	194
		Regression	126	127
	2	Travel Time	-34	123
		MLE	-34	123
		Regression	-75	148
	3	Travel Time	-286	333
		MLE	-286	333
		Regression	-277	320
Egegik River	1	Travel Time	114	177
		MLE	114	177
		Regression	-94	168
	2	Travel Time	-518	591
		MLE	-518	591
		Regression	-547	588
	3	Travel Time	-1,210	1,236
		MLE	-1,210	1,236
		Regression	-1,040	1,065
Ugashik River	1	Travel Time	164	233
		MLE	164	233
		Regression	109	229
	2	Travel Time	-8	50
		MLE	-8	50
		Regression	-31	69
	3	Travel Time	-232	255
		MLE	-232	255
		Regression	-225	248

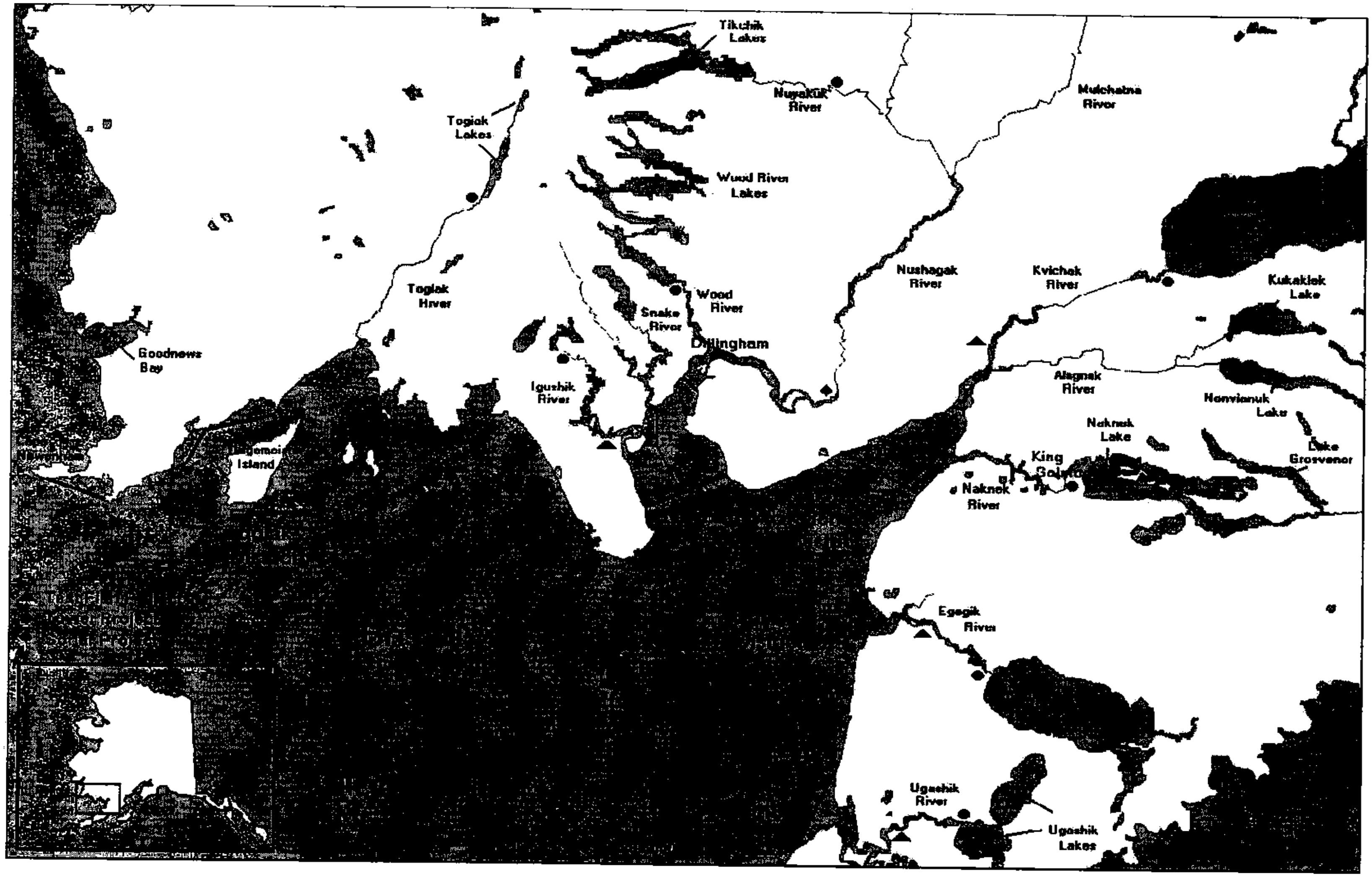
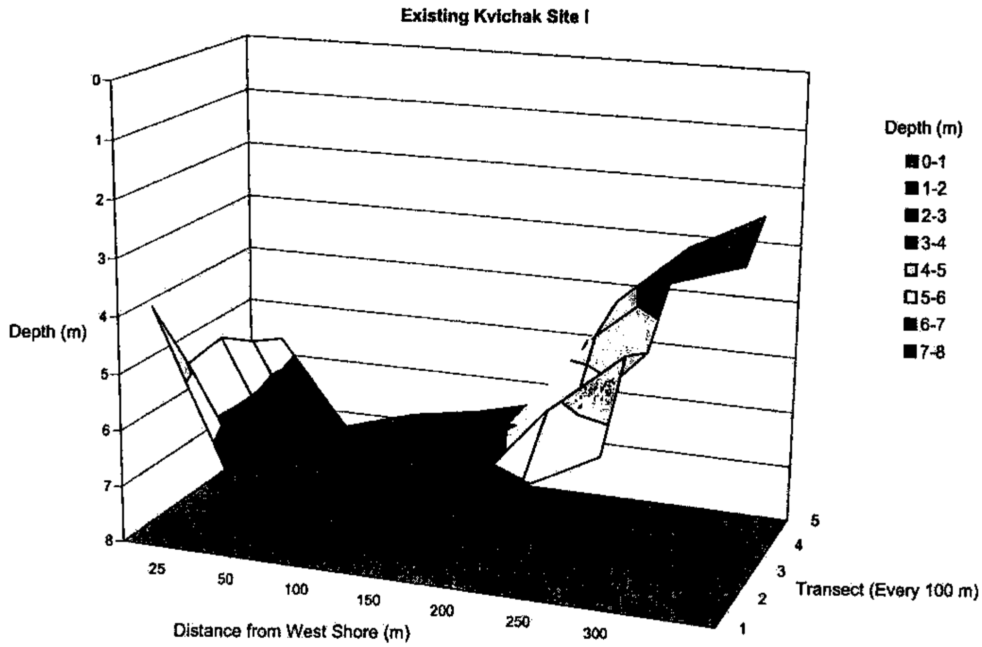


Figure 1. Map of major river systems, commercial salmon fishing districts, test fish sites, tower sites and adult salmon sonar sites, Bristol Bay, Alaska.



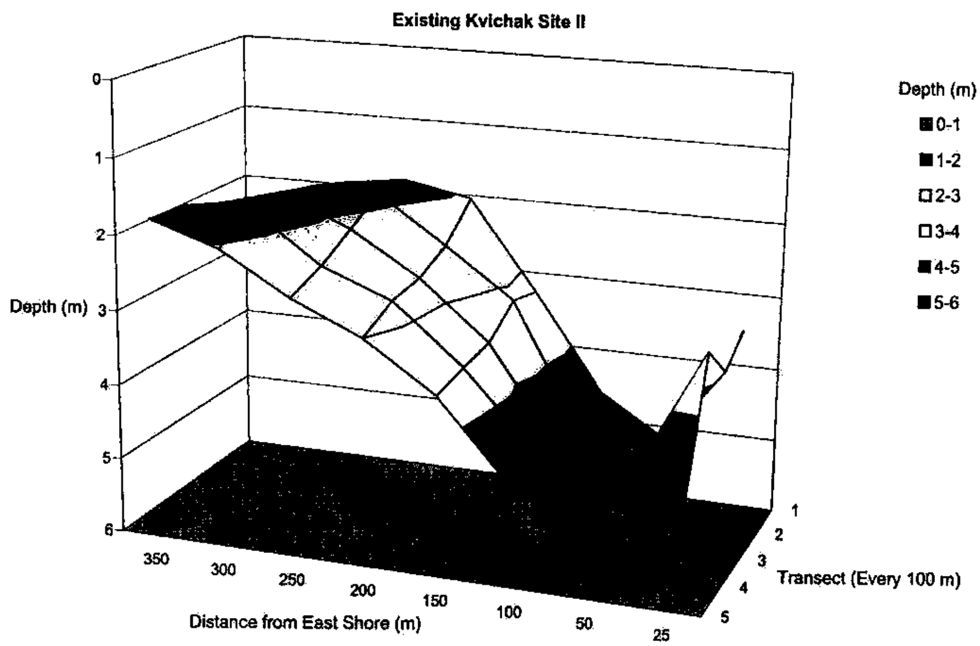
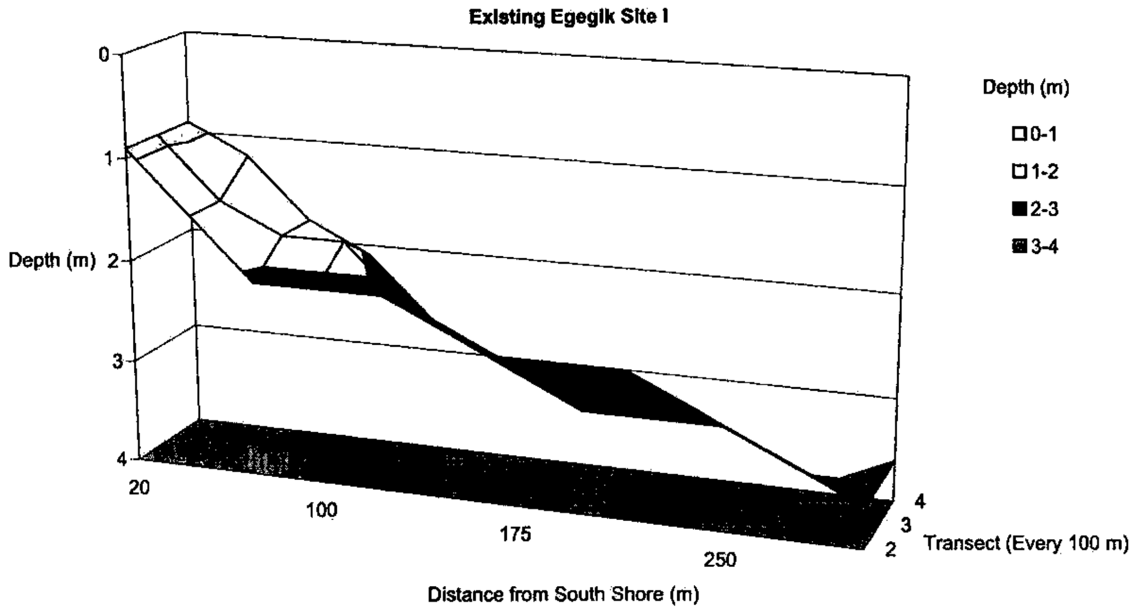


Figure 2. Bathymetric charts of the existing test fish sites, Kvichak River, 2000.



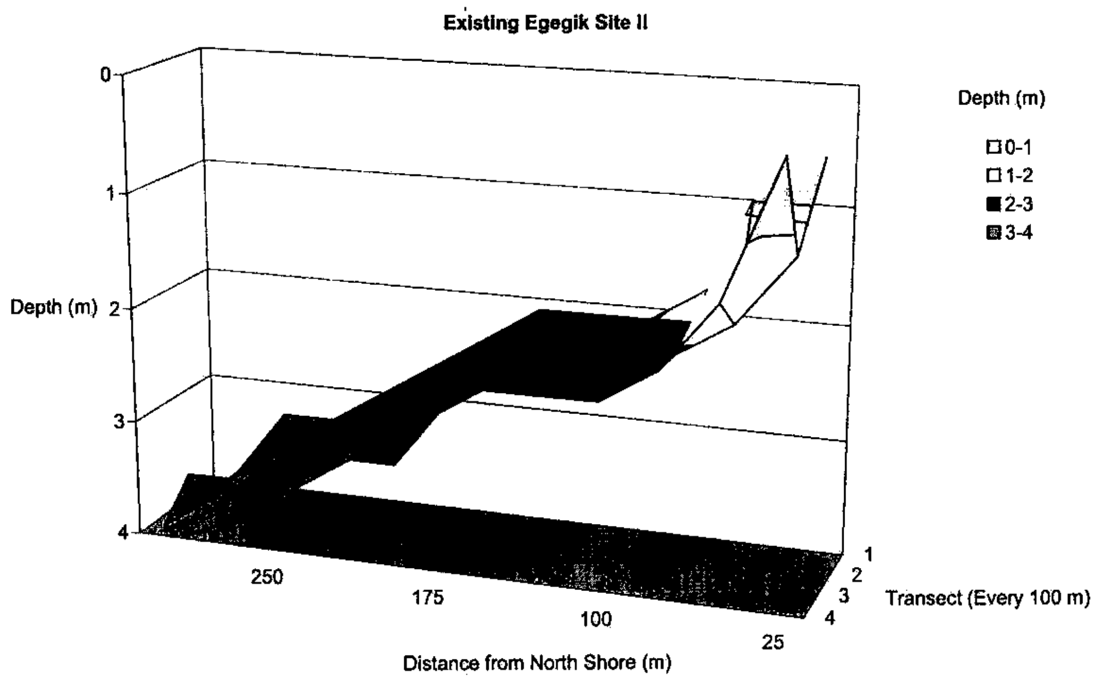
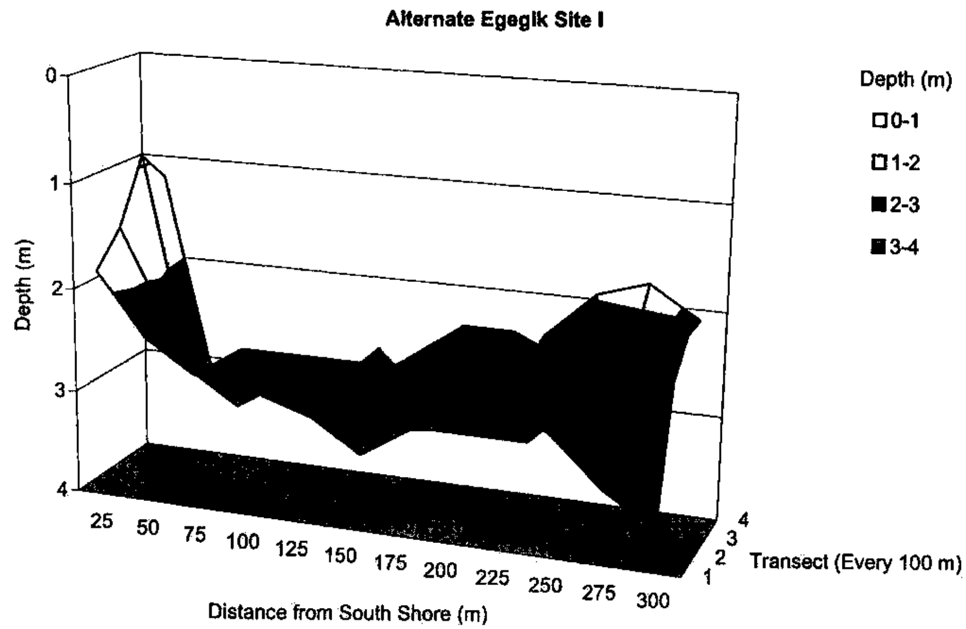


Figure 3. Bathymetric charts of the existing test fish sites, Egegik River, 2000.



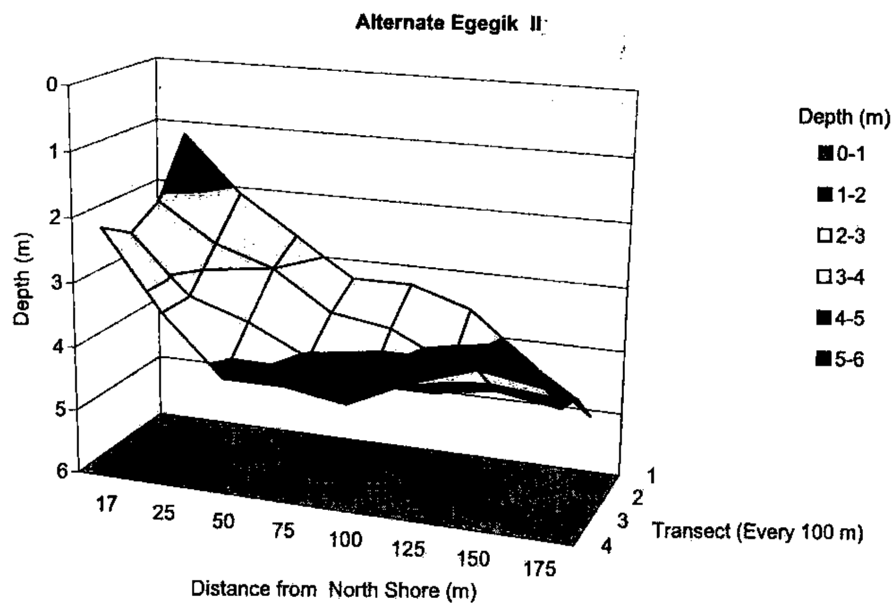
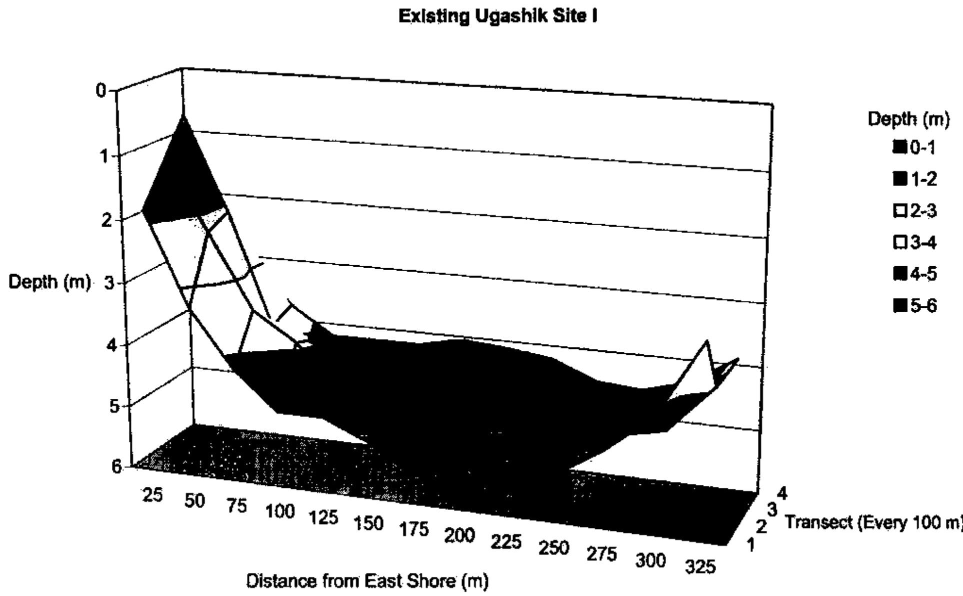


Figure 4. Bathymetric charts of the alternate test fish sites, Egegik River, 2000.



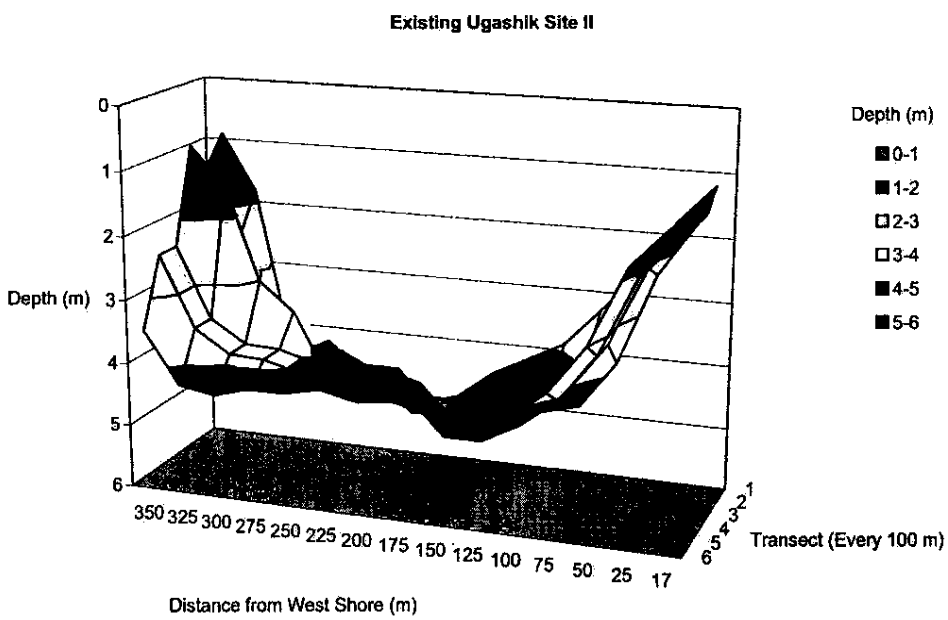
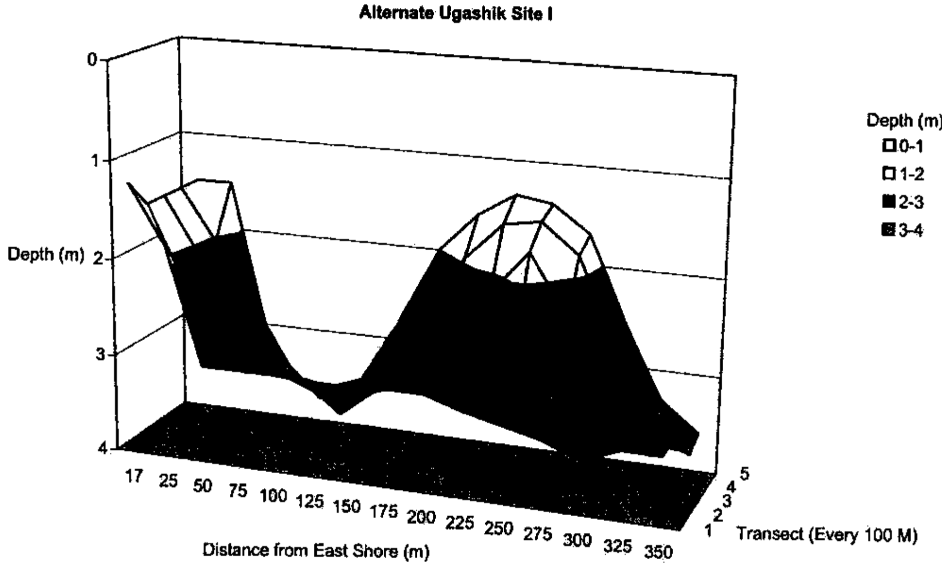


Figure 5. Bathymetric charts of the existing test fish sites, Ugashik River, 2000.



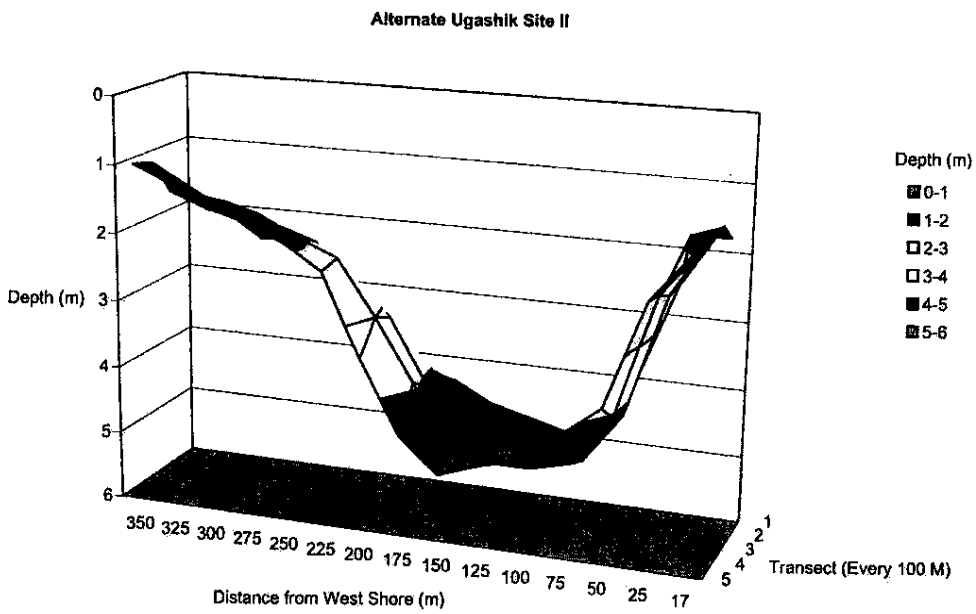


Figure 6. Bathymetric charts of the alternate test fish sites, Ugashik River, 2000.

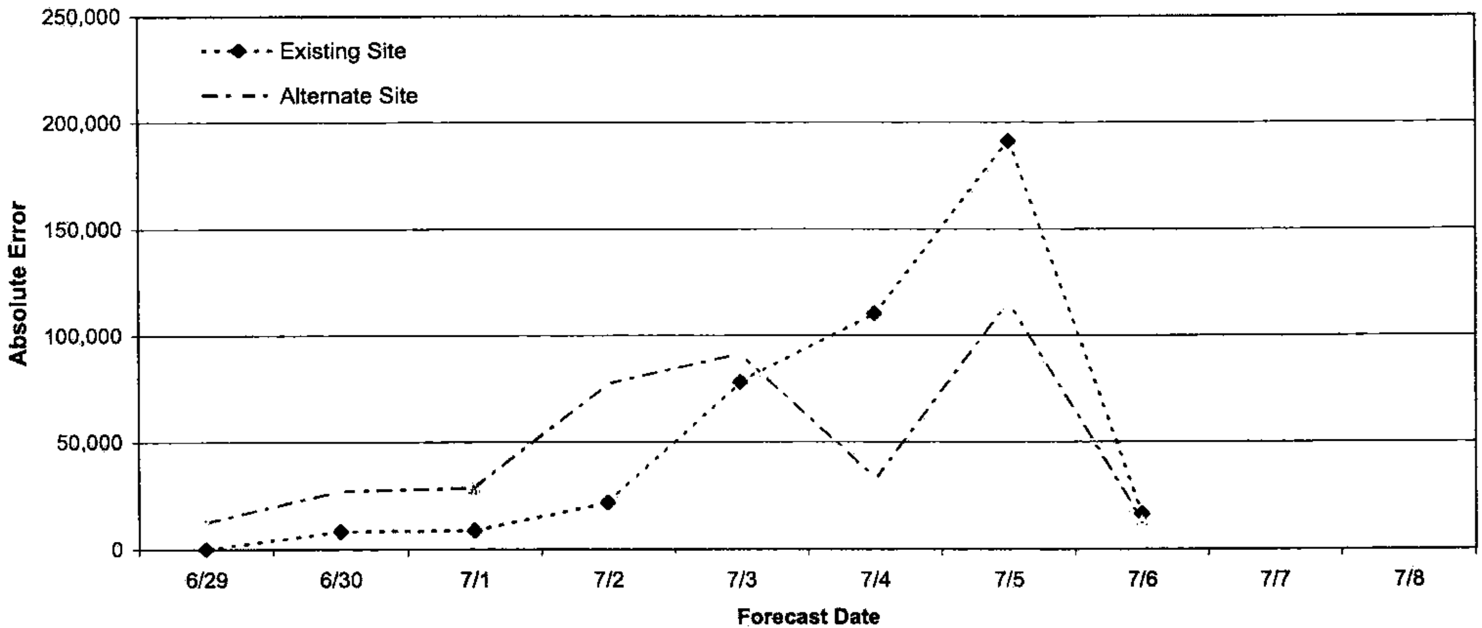


Figure 7. Comparison of the daily absolute errors between the existing and alternate site ERF predictions to the actual lagged escapement, Egegik River, 2000.

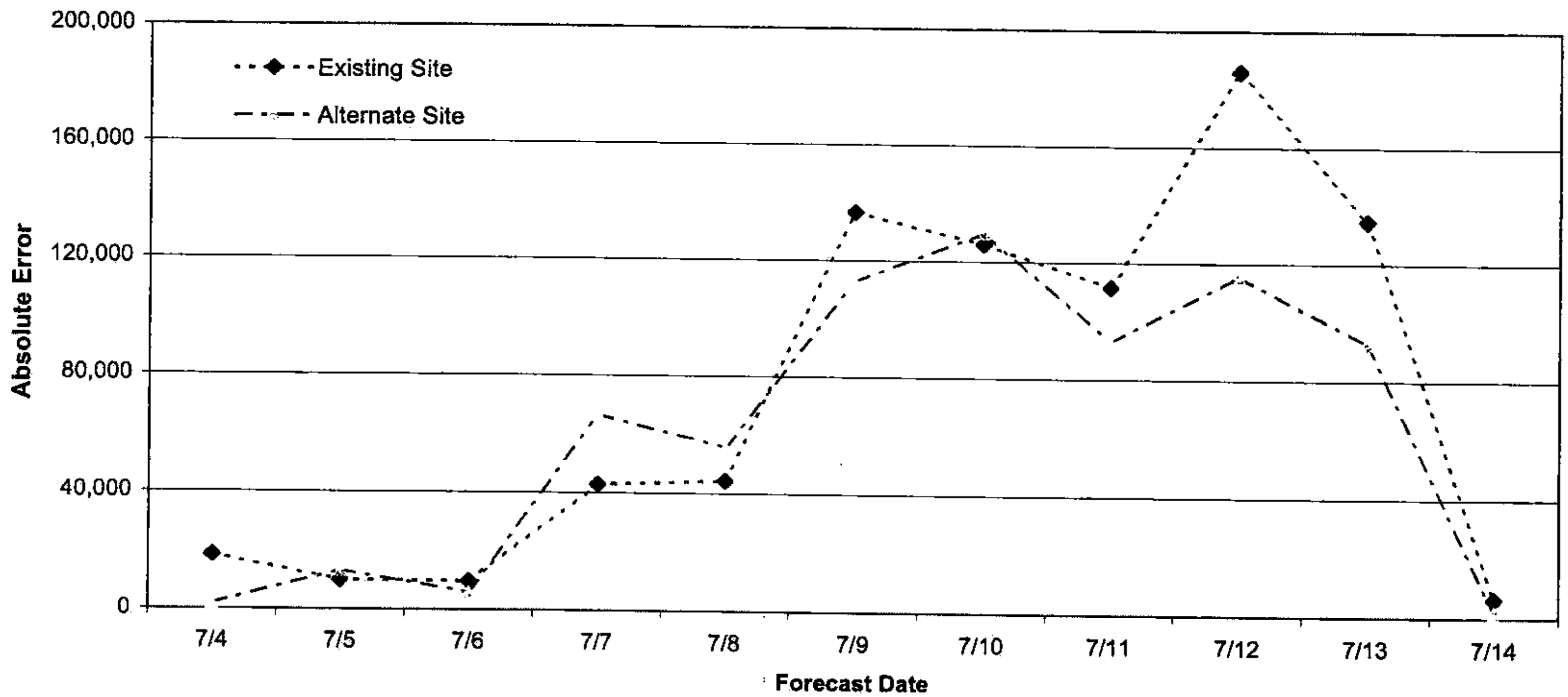


Figure 8. Comparison of the daily absolute errors between the existing and alternate site ERF predictions to the actual lagged escapement, Ugashik River, 2001.

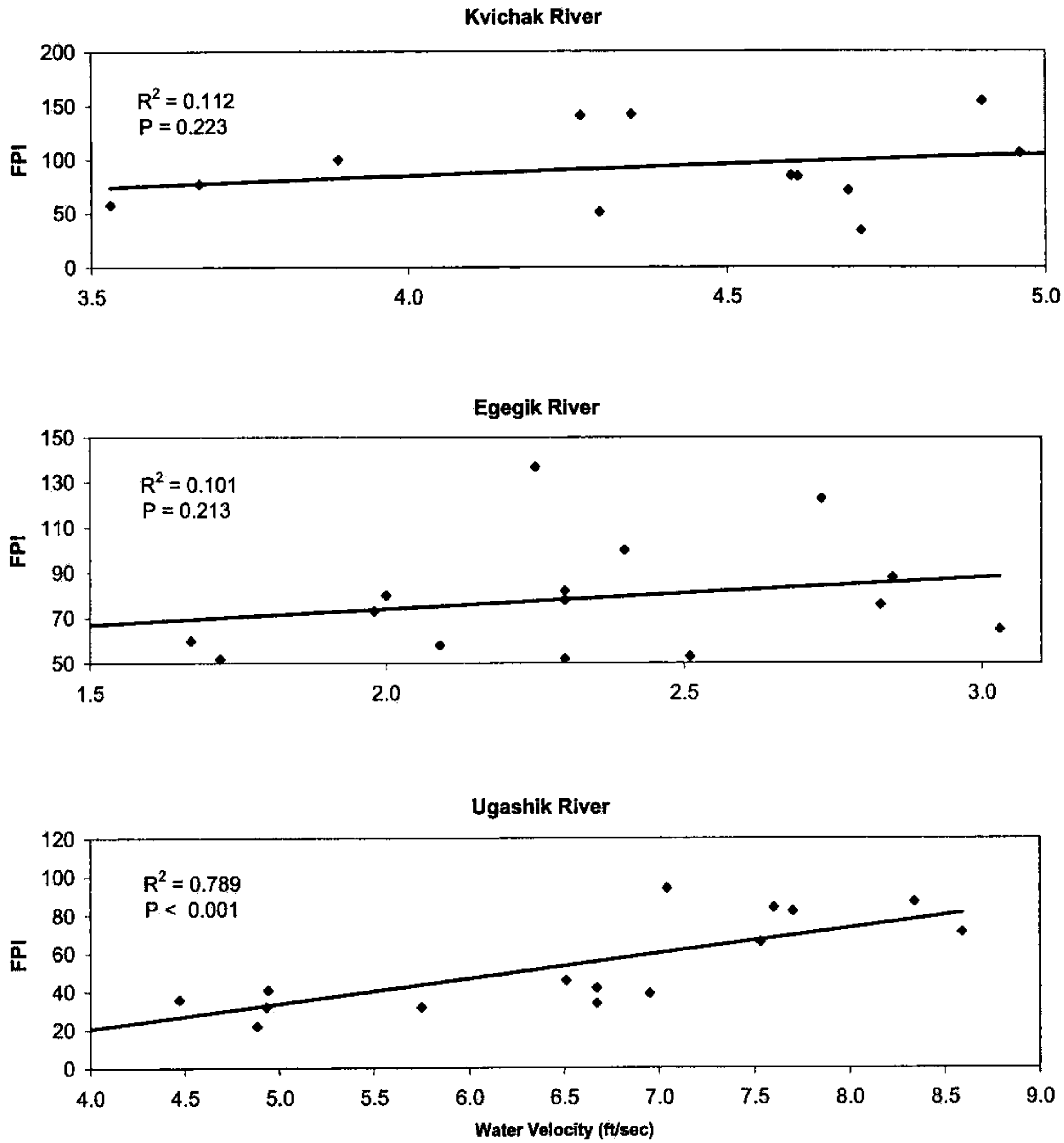


Figure 9. Comparison of FPI (season ending) and water velocities (ft/sec) at Kvichak, Egegik and Ugashik Rivers, 1985-2001.

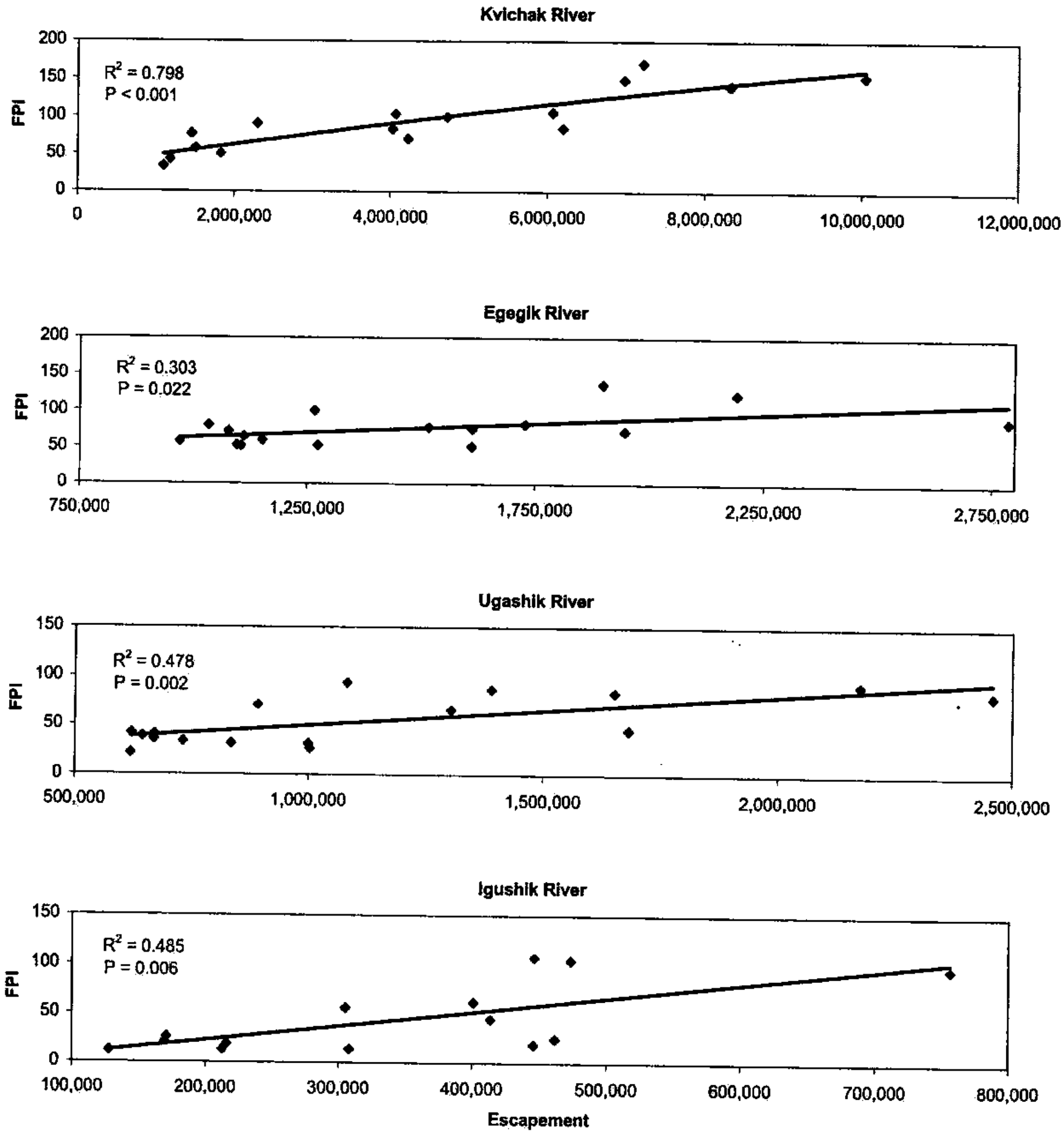


Figure 10. Comparison of FPI (season ending) and escapement of sockeye salmon at Kvichak Egegik, Ugashik and Igushik Rivers, 1985-2001.

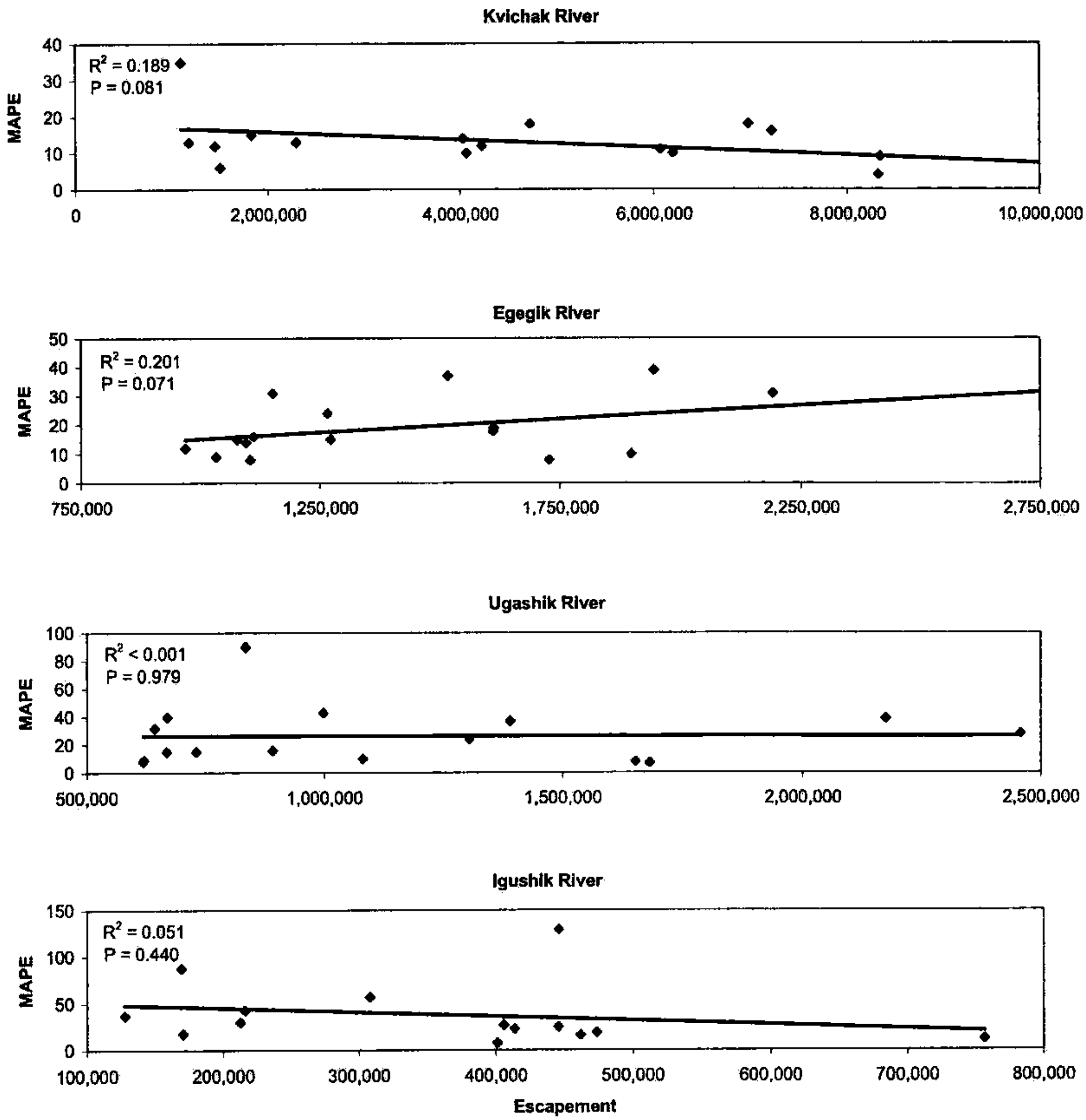


Figure 11. Comparison of MAPE and escapement of sockeye salmon at Kvichak, Egegik, Ugashik and Igushik Rivers, 1985-2001.

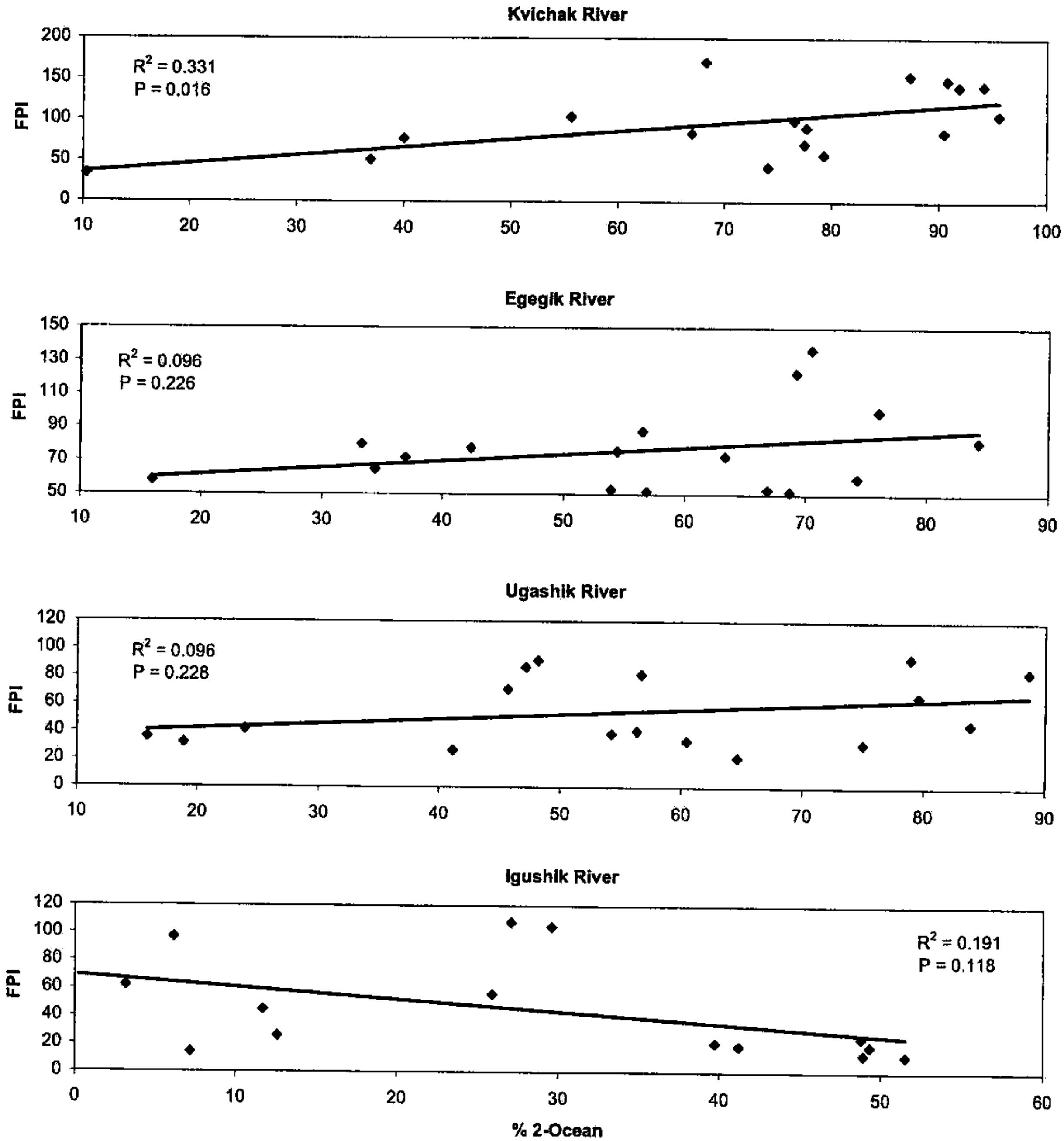


Figure 12. Comparison of FPI (season ending) and % 2-ocean fish in the sockeye salmon escapements at Kvichak Egegik, Ugashik and Igushik Rivers, 1985-2001.

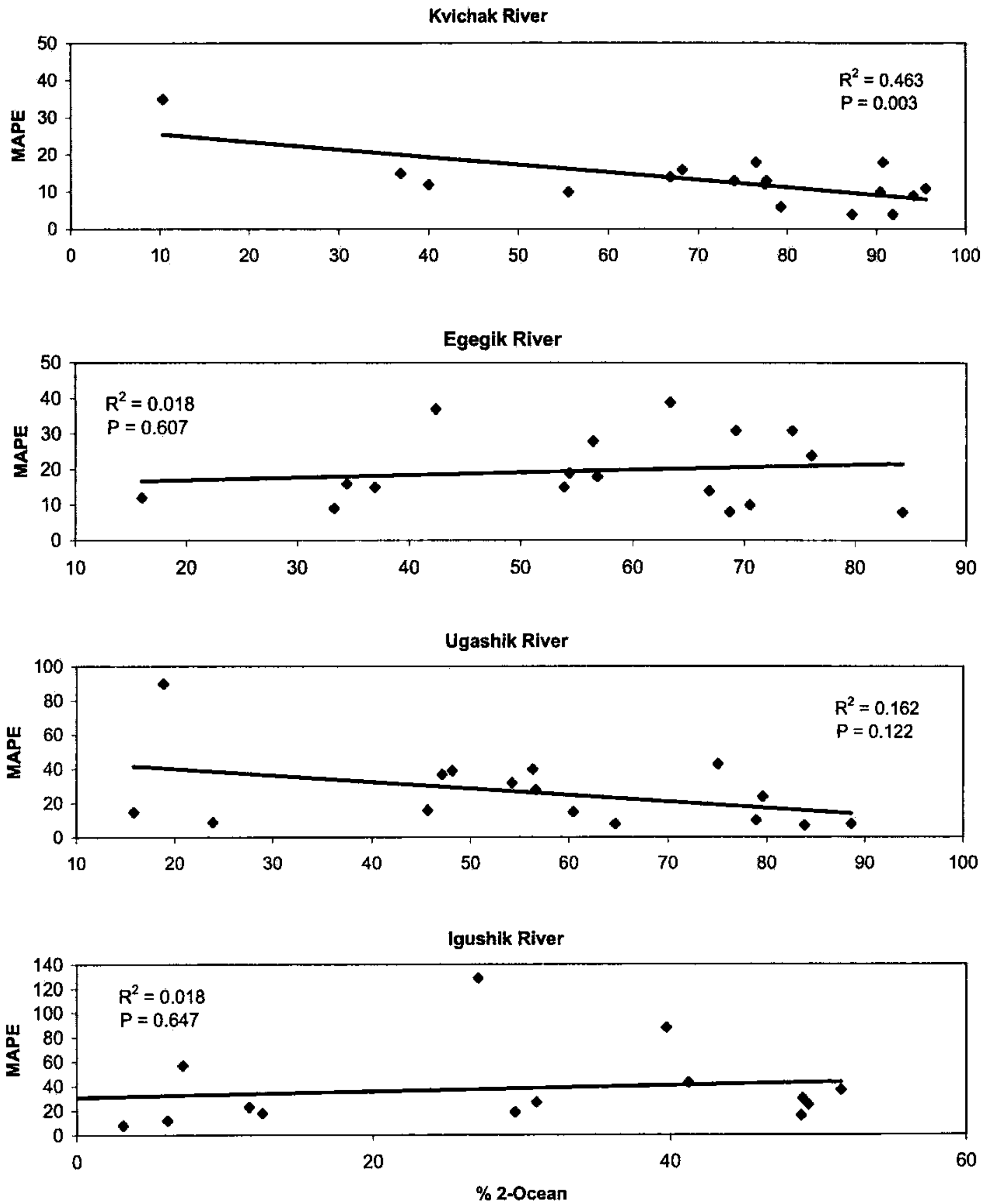


Figure 13. Comparison of MAPE and % 2-ocean fish in the sockeye salmon escapements at Kvichak, Egegik, Ugashik and Igushik Rivers, 1985-2001.

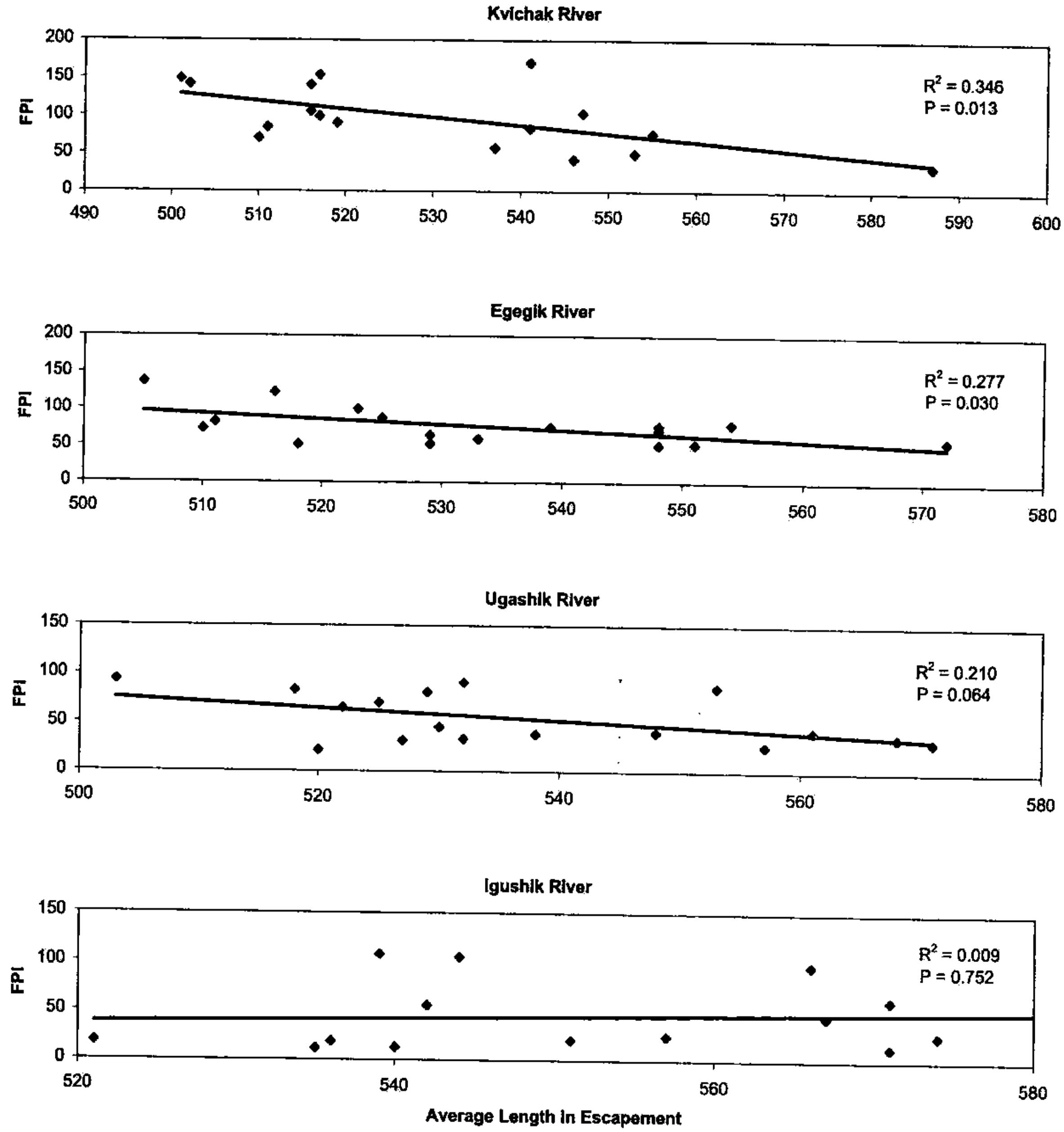


Figure 14. Comparison of FPI (season ending) and average length of sockeye salmon escapements at Kvichak, Egegik, Ugashik and Igushik Rivers, 1985-2001.

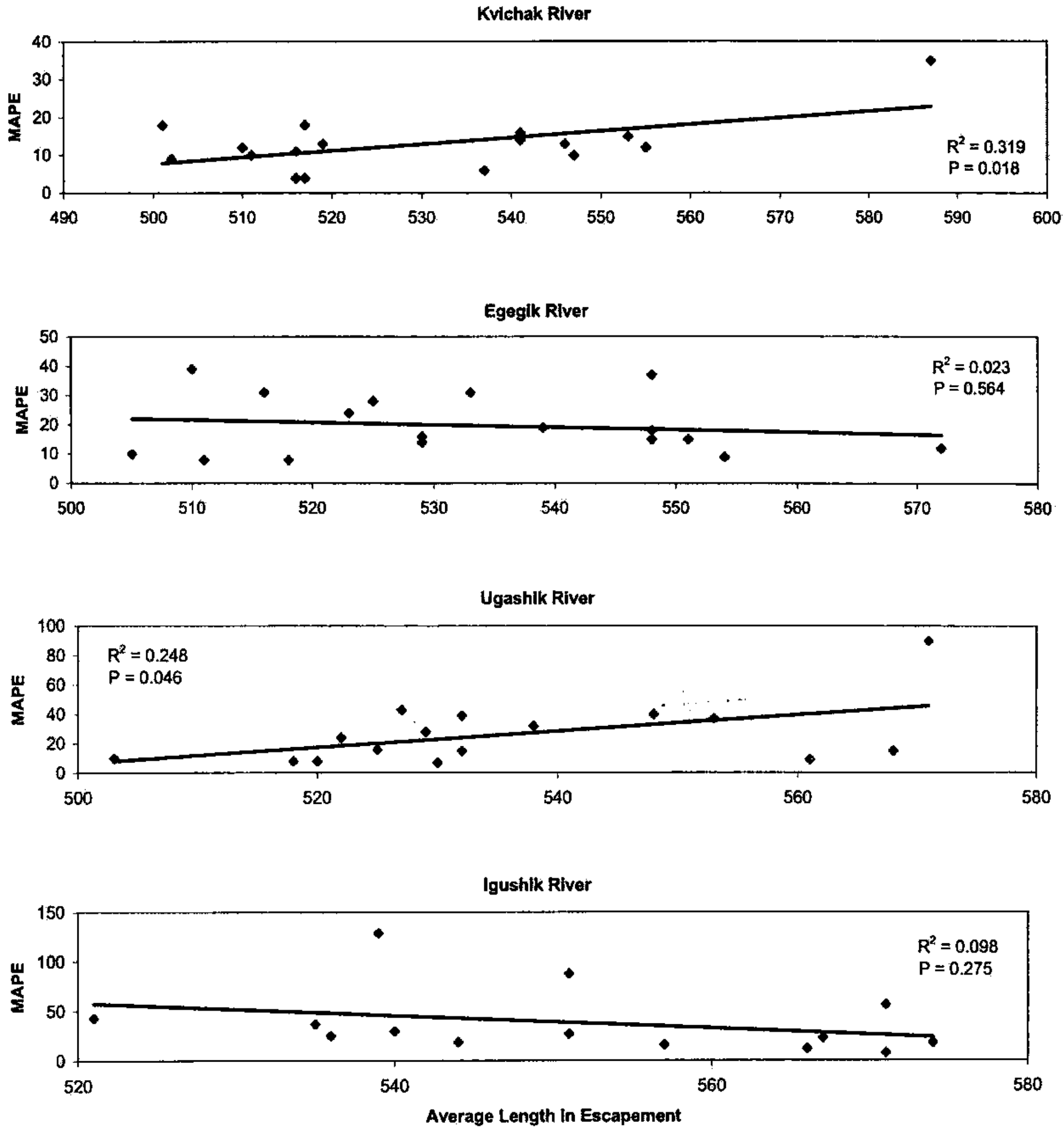


Figure 15. Comparison of MAPE and average length of sockeye salmon escapements at Kvichak, Egegik, Ugashik, and Igushik Rivers, 1985-2001.

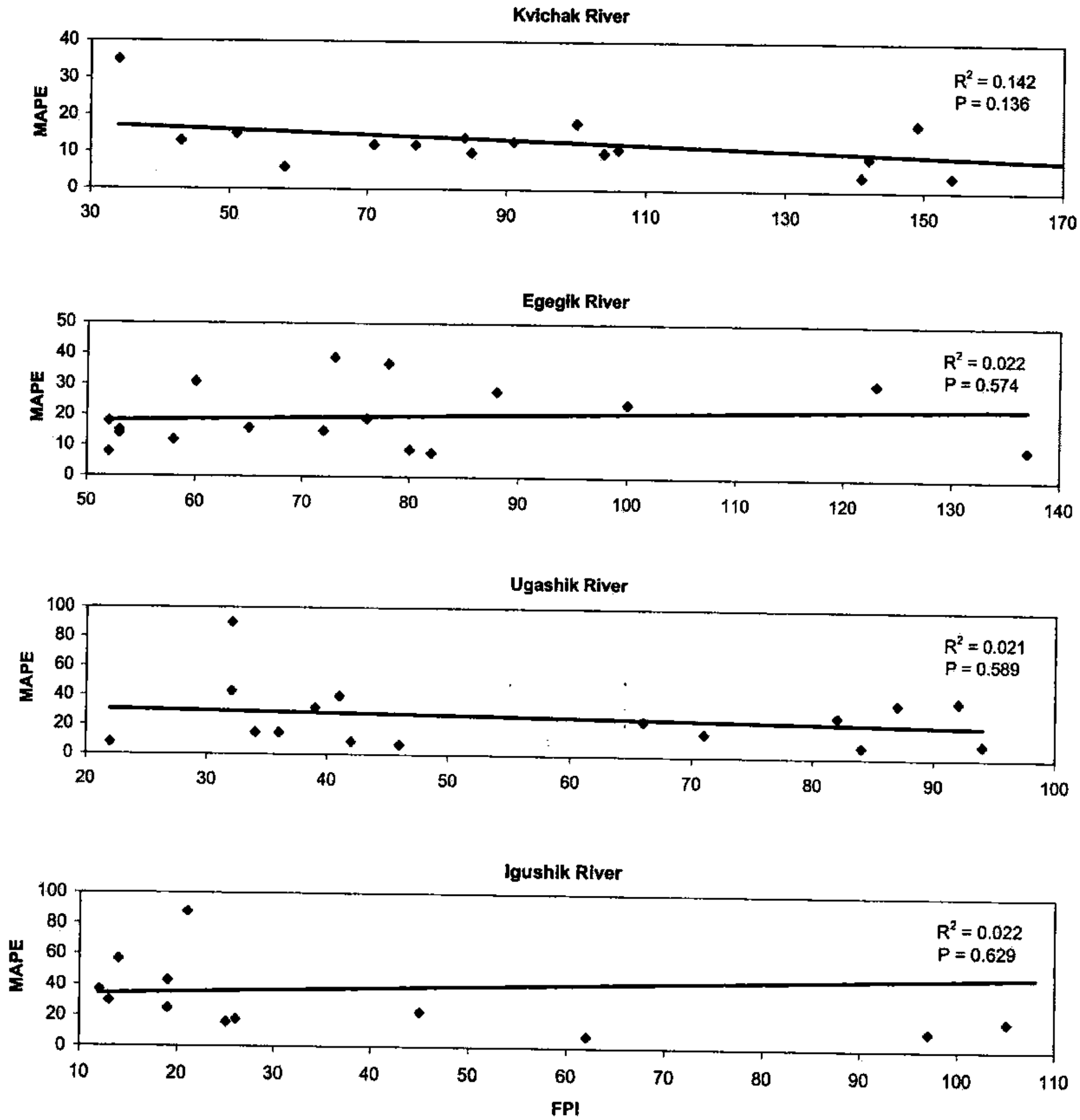


Figure 16. Comparison of MAPE and FPI (season ending) of the inriver test fisheries at Kvichak, Egegik, Ugashik and Igushik Rivers, 1985-2001.

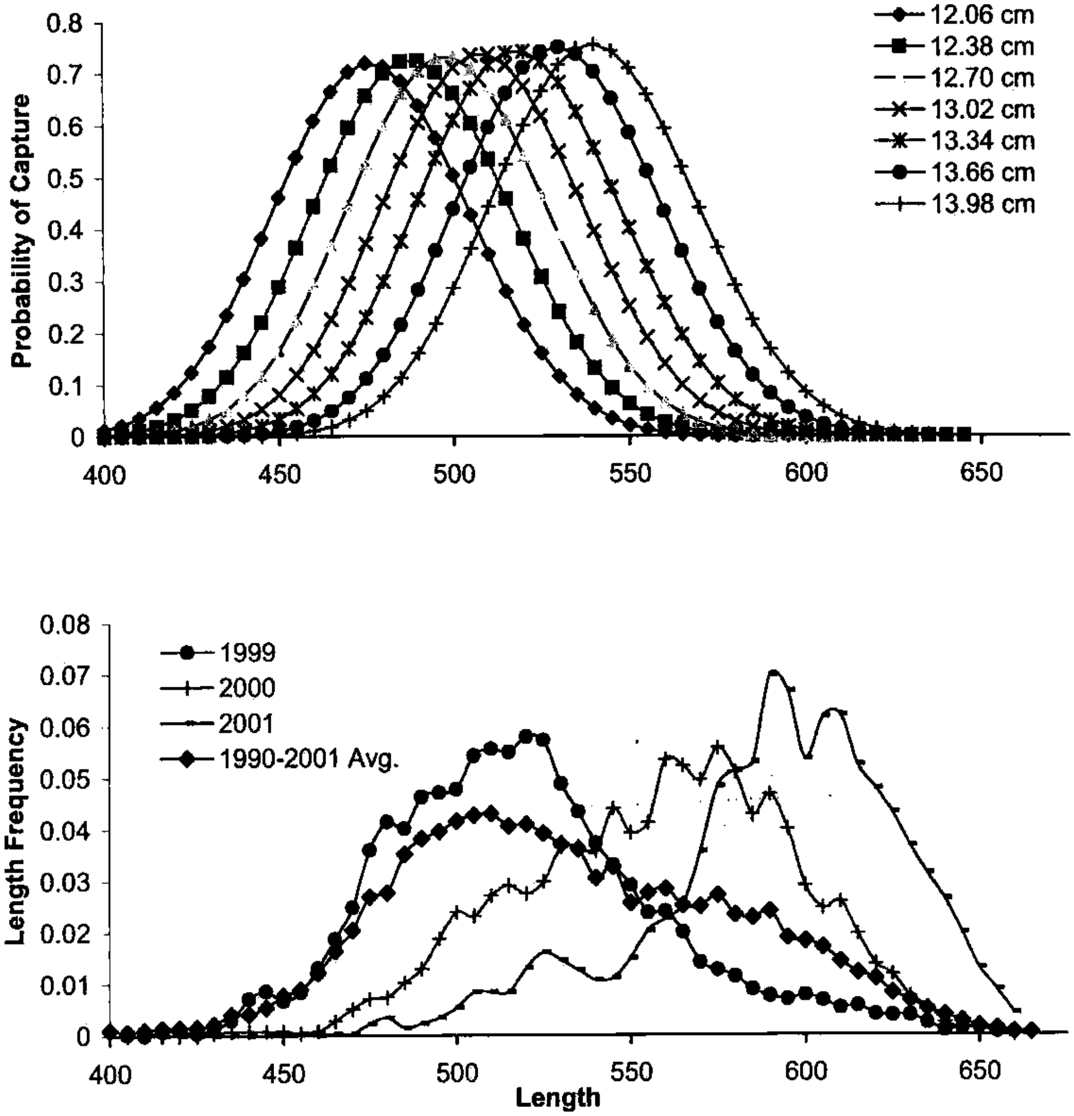


Figure 17. Gillnet selectivity curves (top) and length frequencies of sockeye salmon escapements (bottom), Kvichak River.

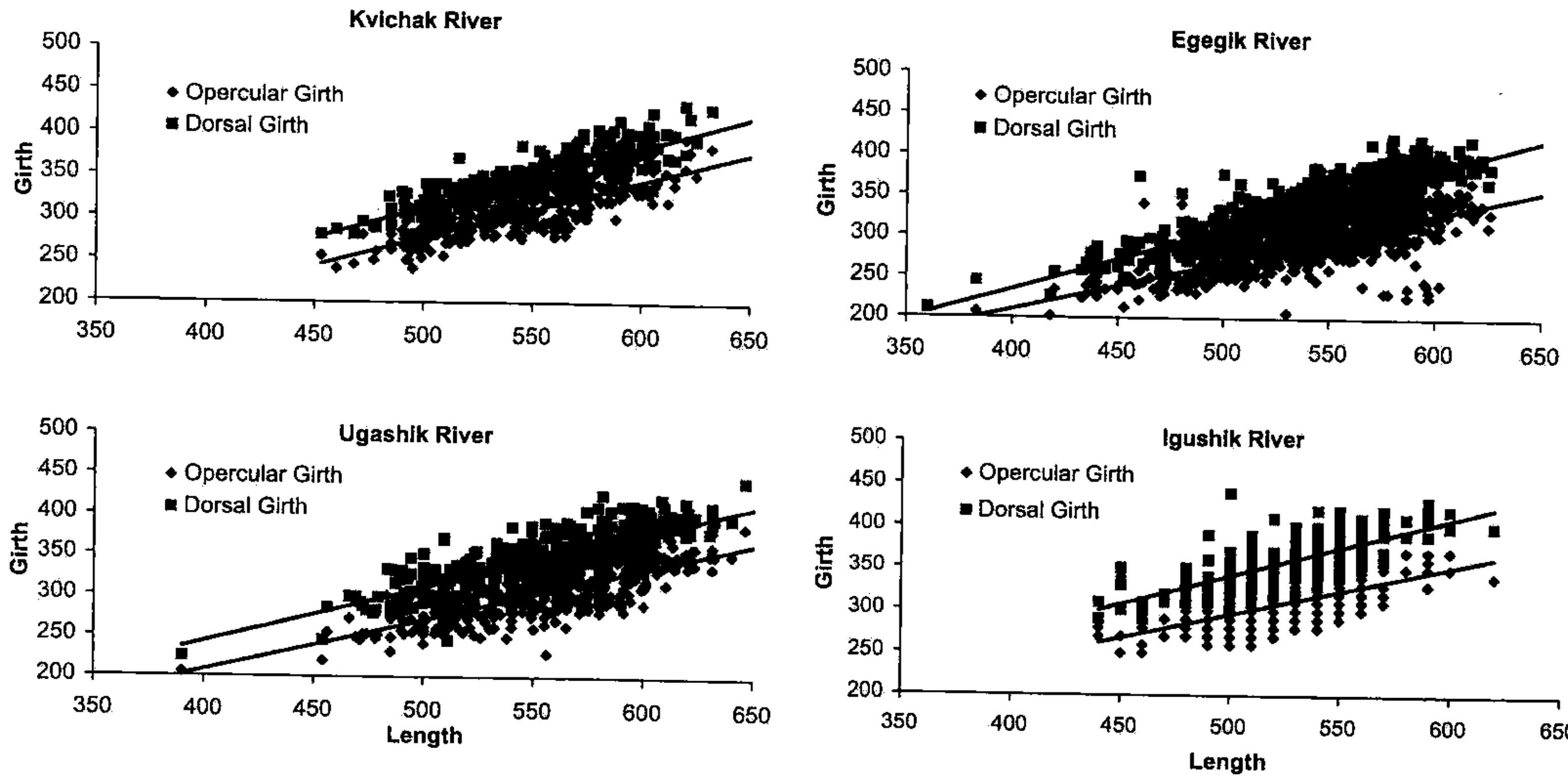


Figure 18. Length and girth information from sockeye salmon sampled at the Kvichak, Egegik, Ugashik and Igushik test fish sites, 2000.

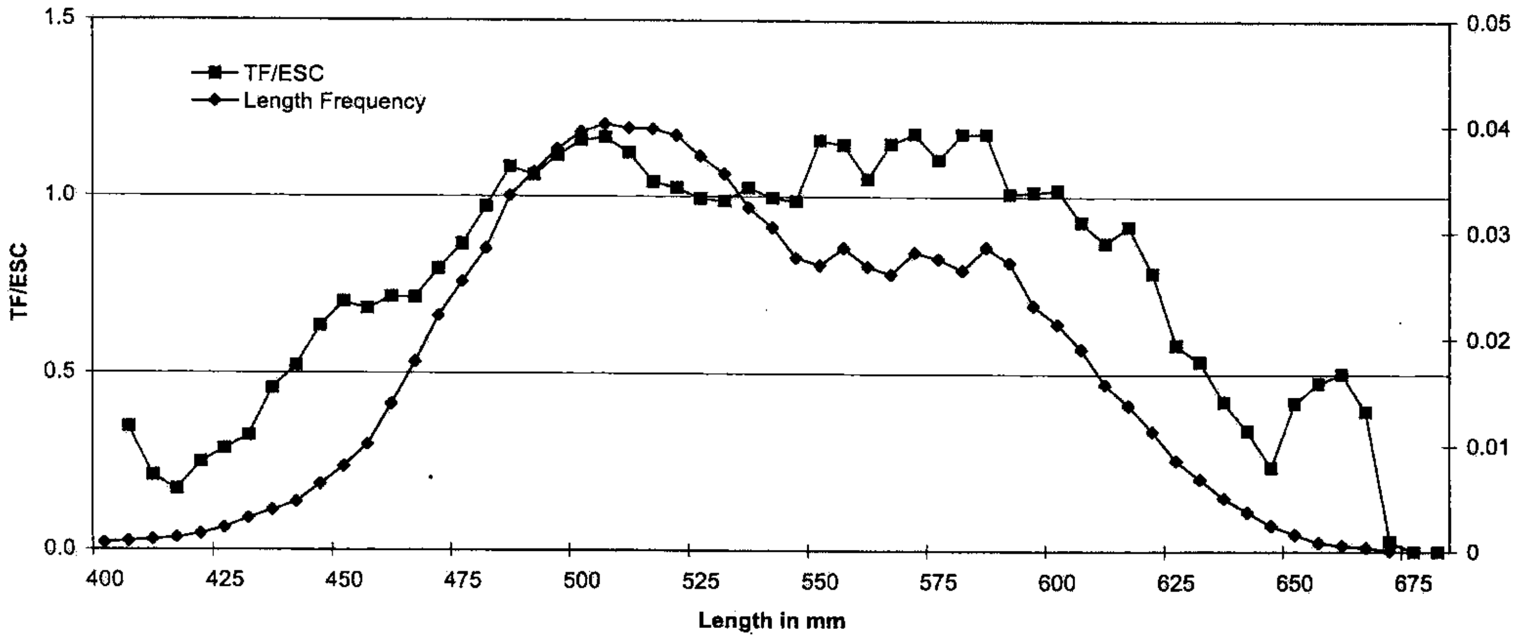
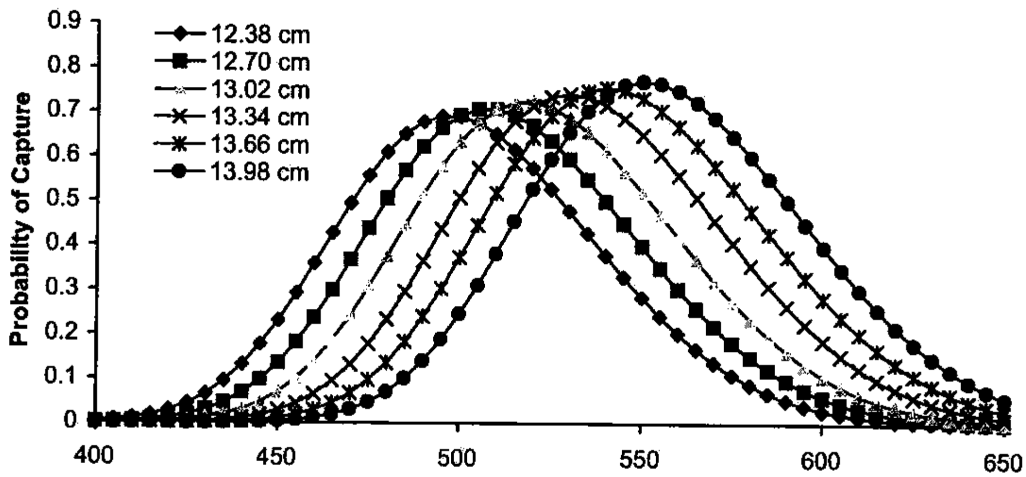


Figure 19. Proportion of fish, by length class, caught with 12.7 cm (5.0 in) mesh gillnet at the test fishery site divided by the proportion of fish, by length class, captured with beach seine at the tower site, with combined yearly escapement length frequencies, Kvichak River, 1988-1992, 1995-1996, and 2000-2001.



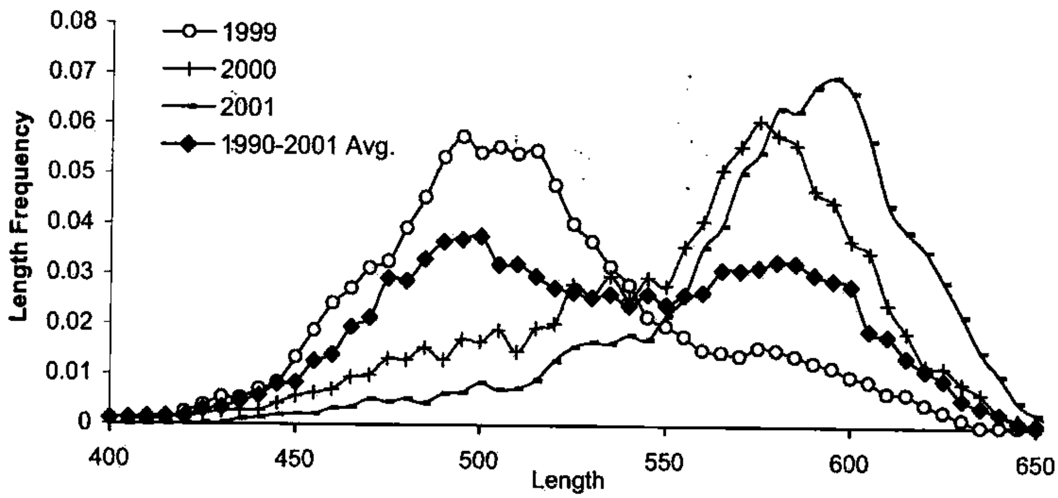


Figure 20. Gillnet selectivity curves (top) and length frequencies of sockeye salmon escapements (bottom), Egegik River.

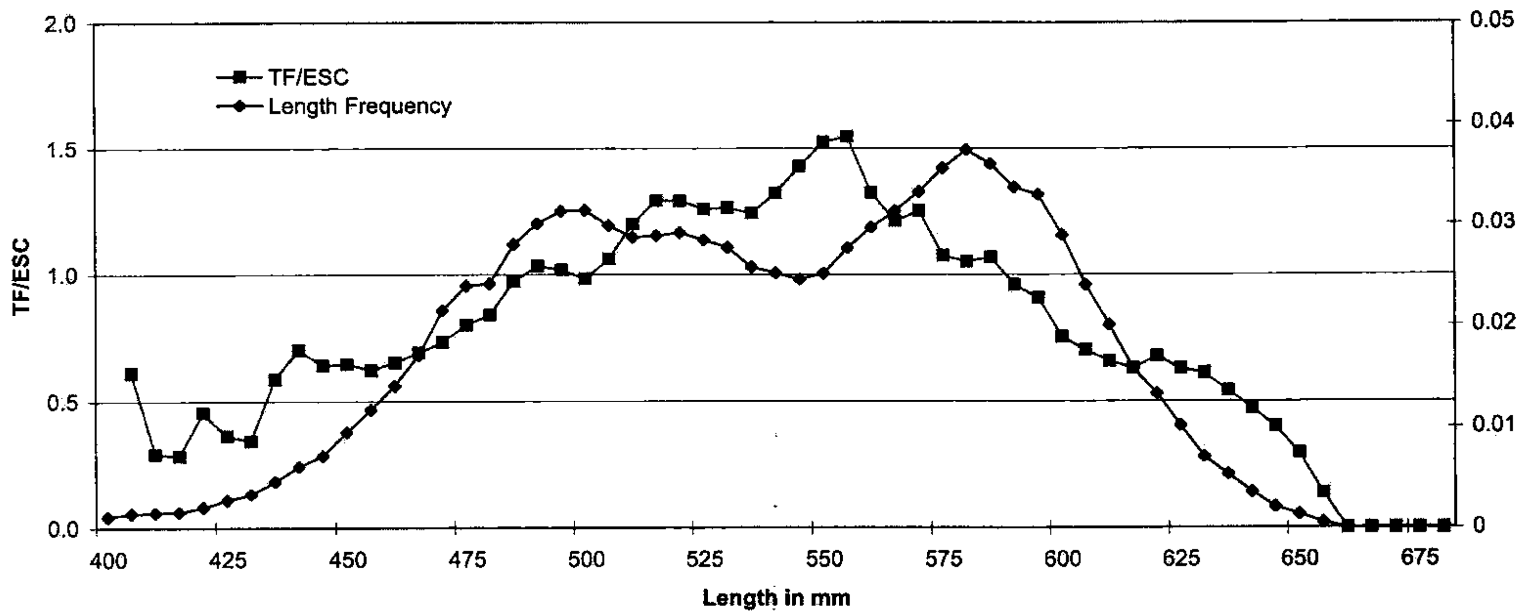
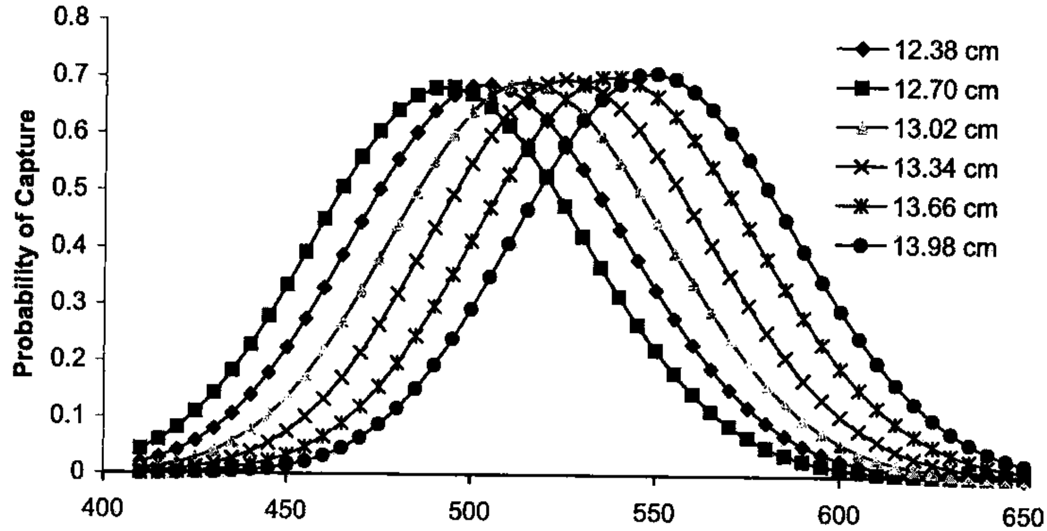


Figure 21. Proportion of fish, by length class, caught with 13.20 cm (5-1/8 in) mesh gillnet at the test fishery site divided by the proportion of fish, by length class, captured with beach seine at the tower site, with combined yearly escapement length frequencies, Egegik River, 1988-1992, 1995-1996, and 2000-2001.



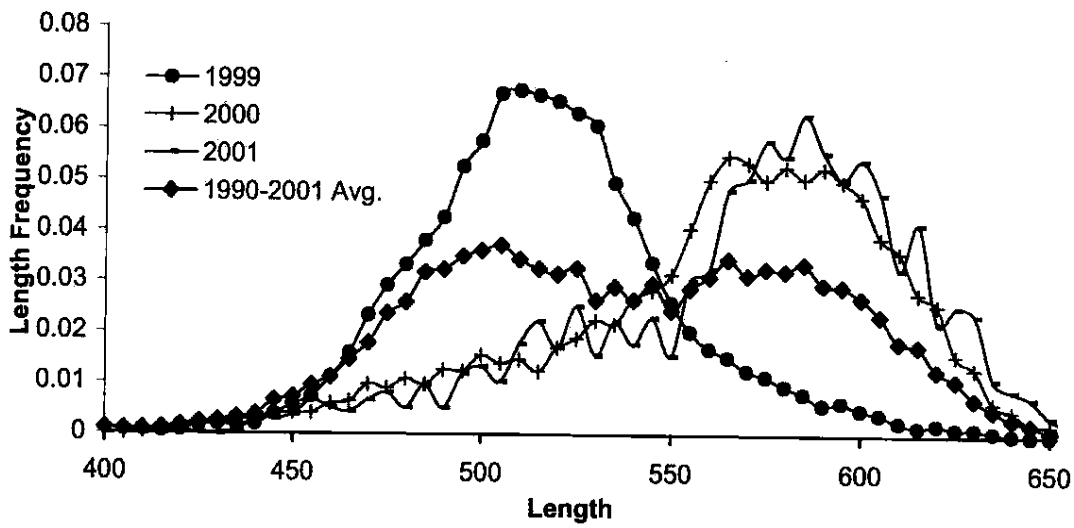


Figure 22. Gillnet selectivity curves (top) and length frequencies of sockeye salmon escapements (bottom), Ugashik River.

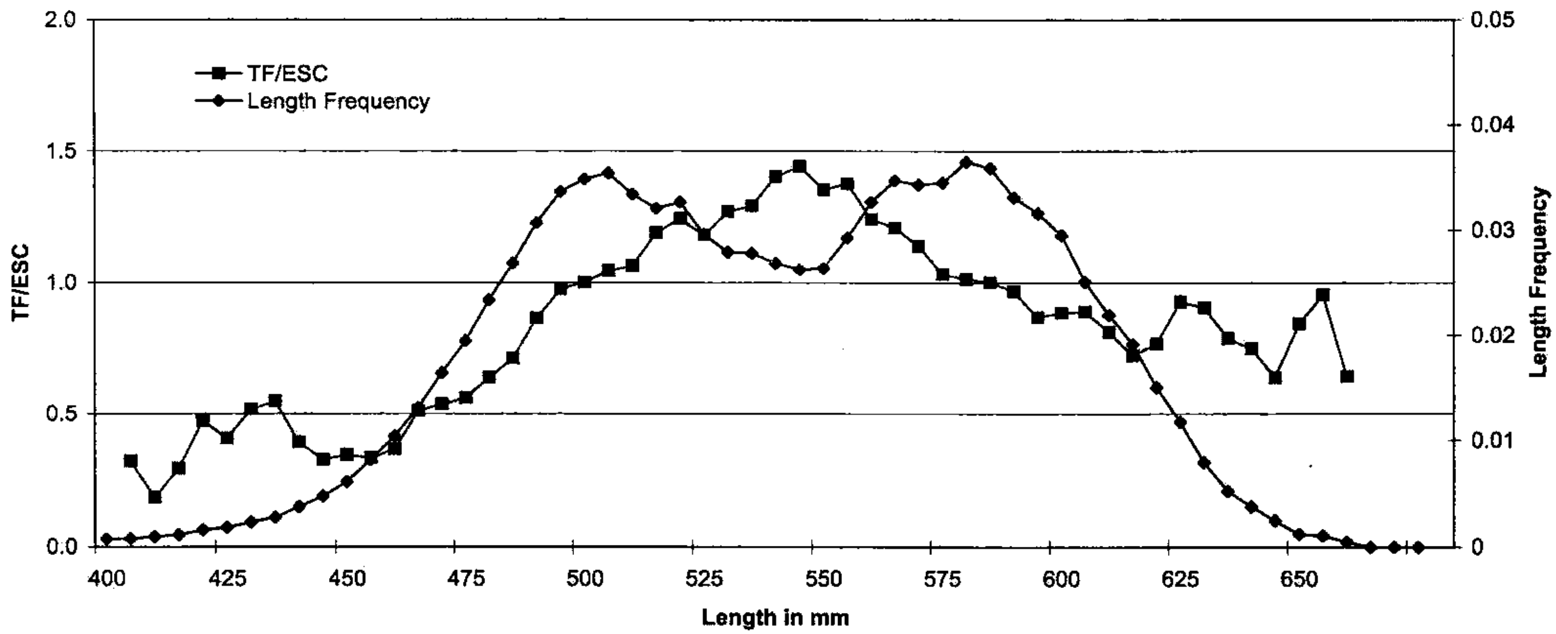


Figure 23. Proportion of fish, by length class, caught with 13.20 cm (5-1/8 in) mesh gillnet at the test fishery site divided by the proportion of fish, by length class, captured with beach seine at the tower site, with combined yearly escapement length frequencies, Ugashik River, 1988-1992, 1995-1996, and 2000-2001.

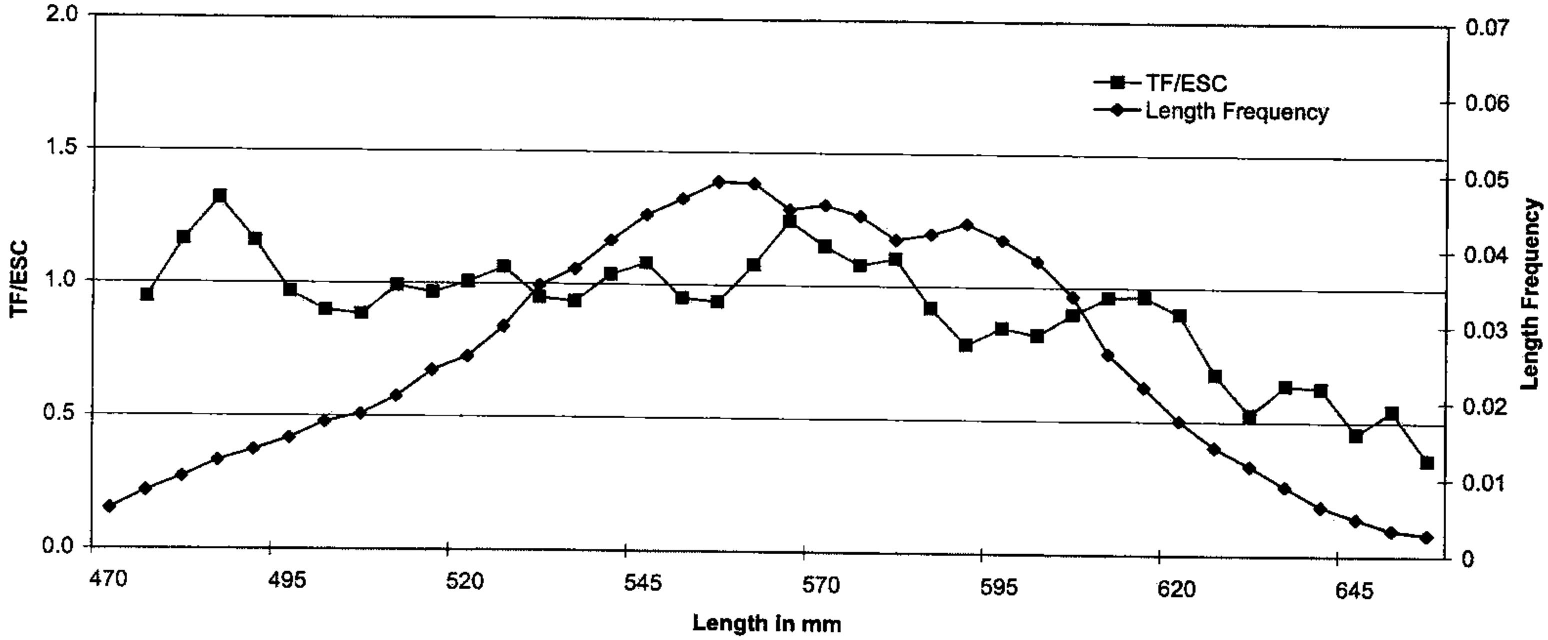


Figure 24. Proportion of fish, by length class, caught with 13.20 cm (5-1/8 in) mesh gillnet at the test fishery site divided by the proportion of fish, by length class, captured with beach seine at the tower site, with combined yearly escapement length frequencies, Igushik River, 1989, 1991-1992, 1995 and 1996.

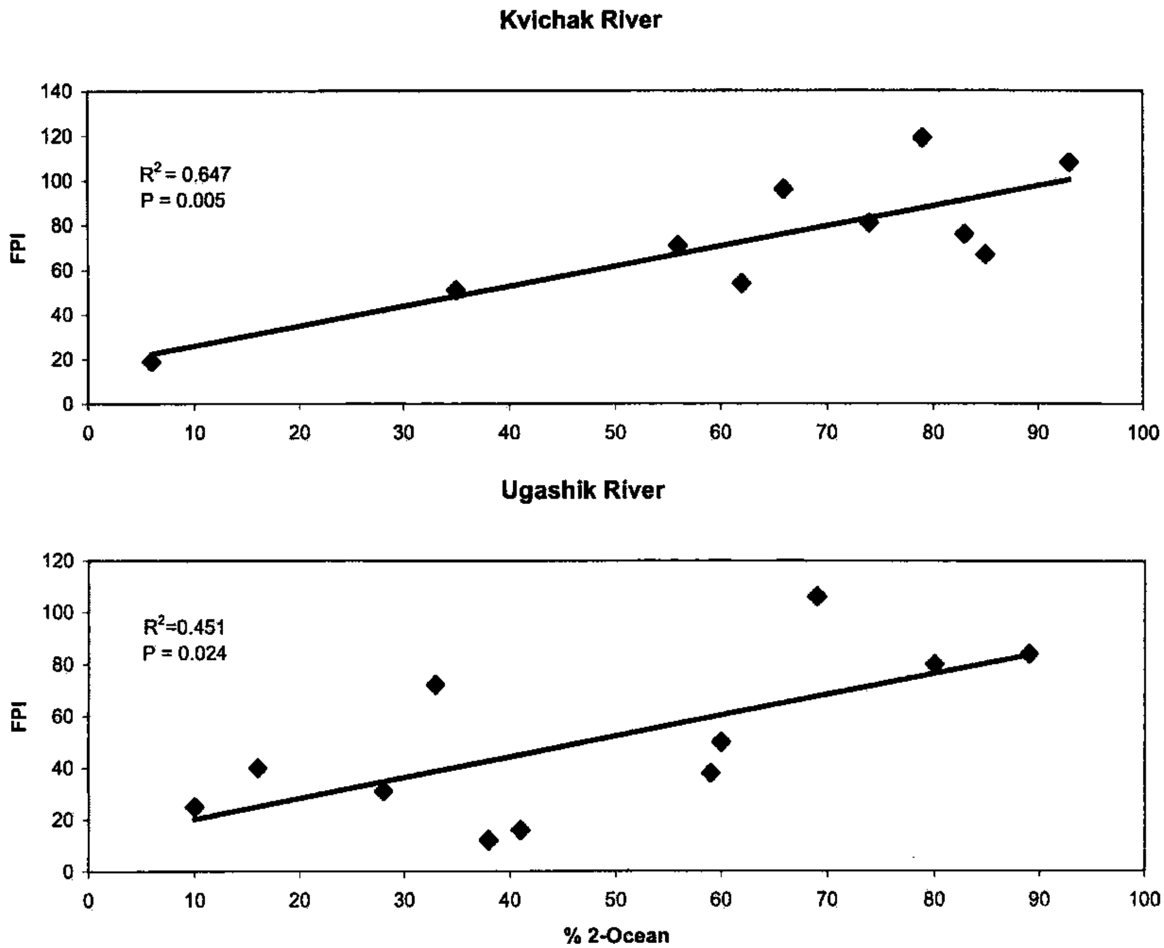


Figure 25. Comparison of FPI (3 day average after "lock-in" occurred) and % 2-ocean fish in the sockeye salmon escapements prior to the date of "lock-in", Kvichak and Ugashik Rivers, 1991-2001.

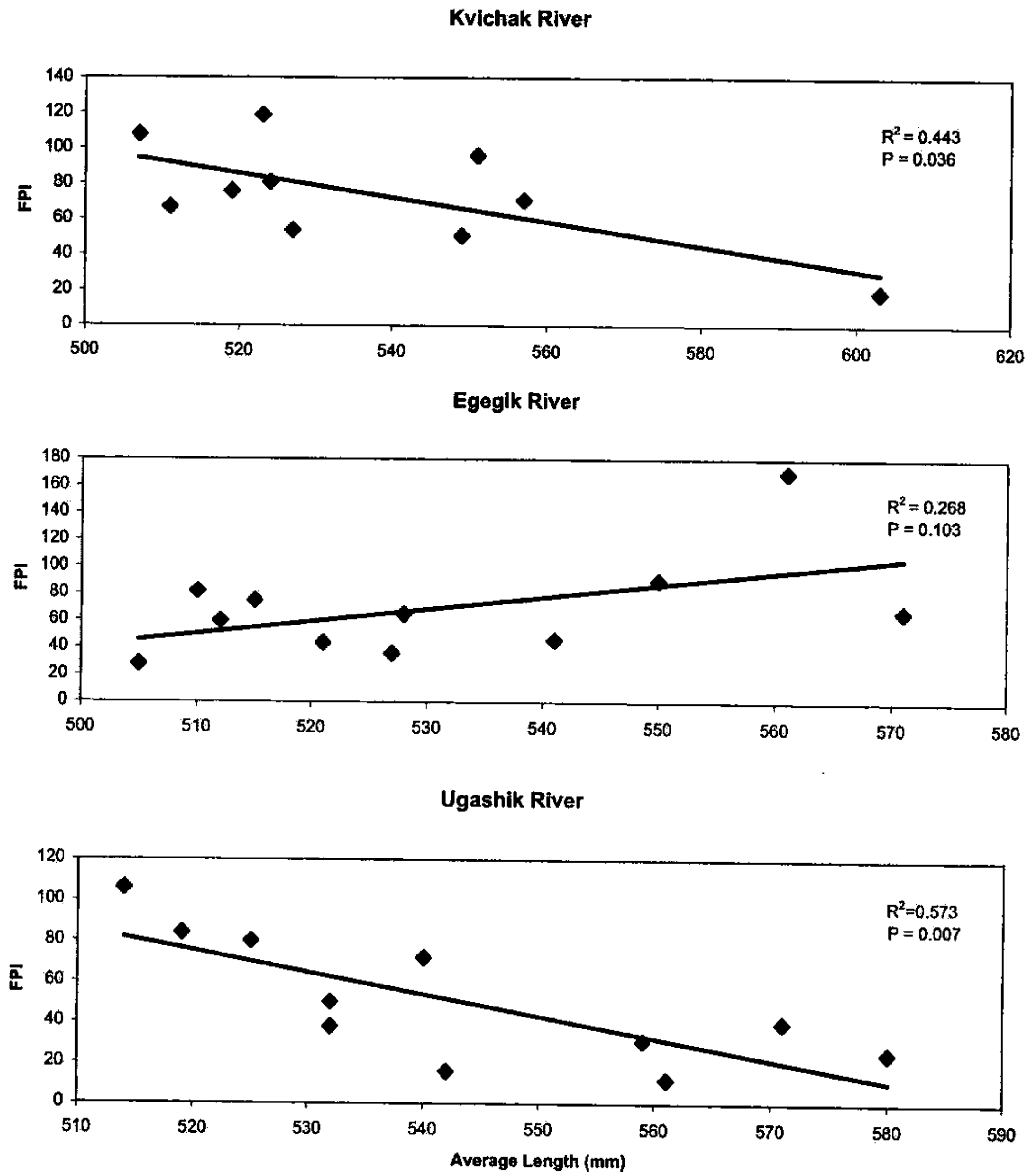


Figure 26. Comparison of FPI (3 day average after "lock-in" occurred) and average length in the sockeye salmon escapments prior to the date of "lock-in", Kvichak, Egegik and Ugashik Rivers, 1991-2001.

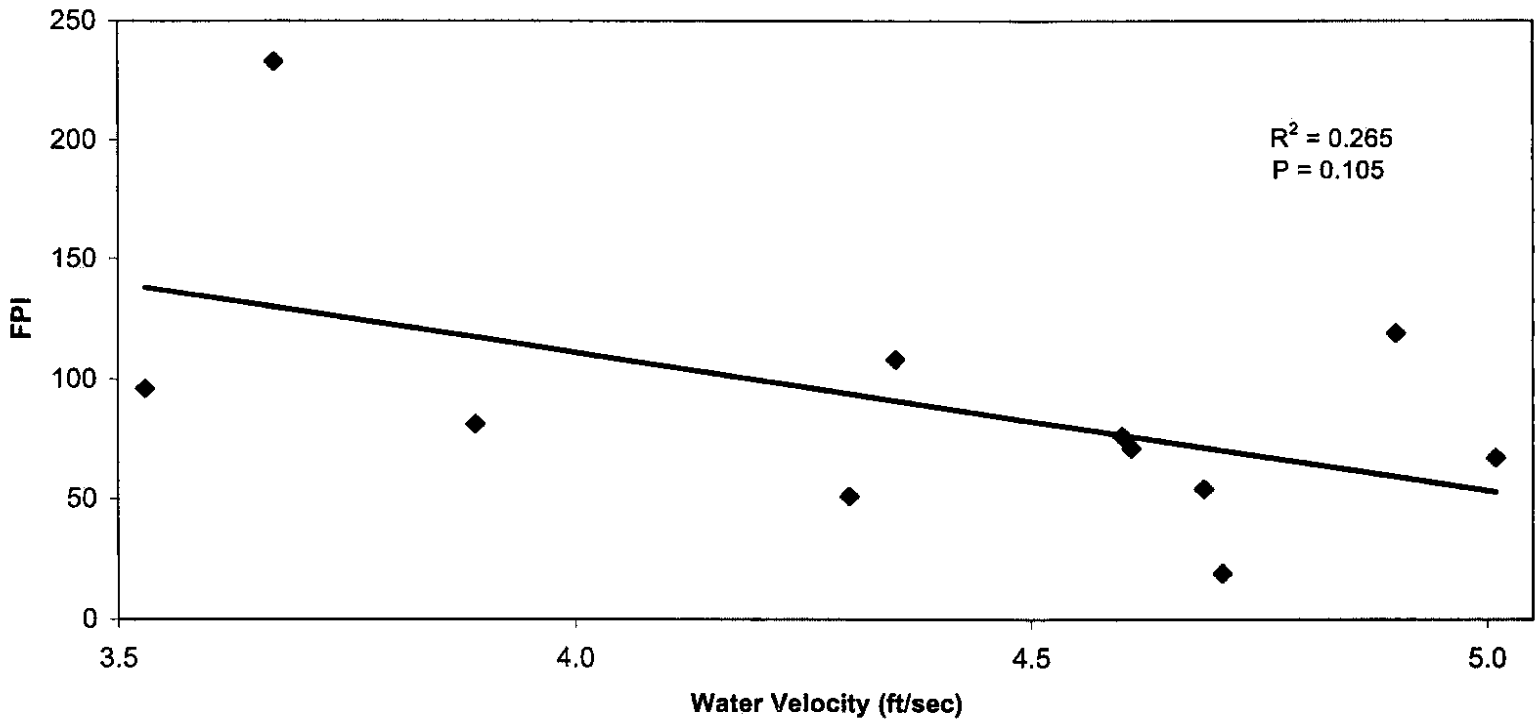


Figure 27. Comparison of FPI (3 day average after "lock-in" occurred) and related water velocity measurements, Kvichak River, 1991-2001.

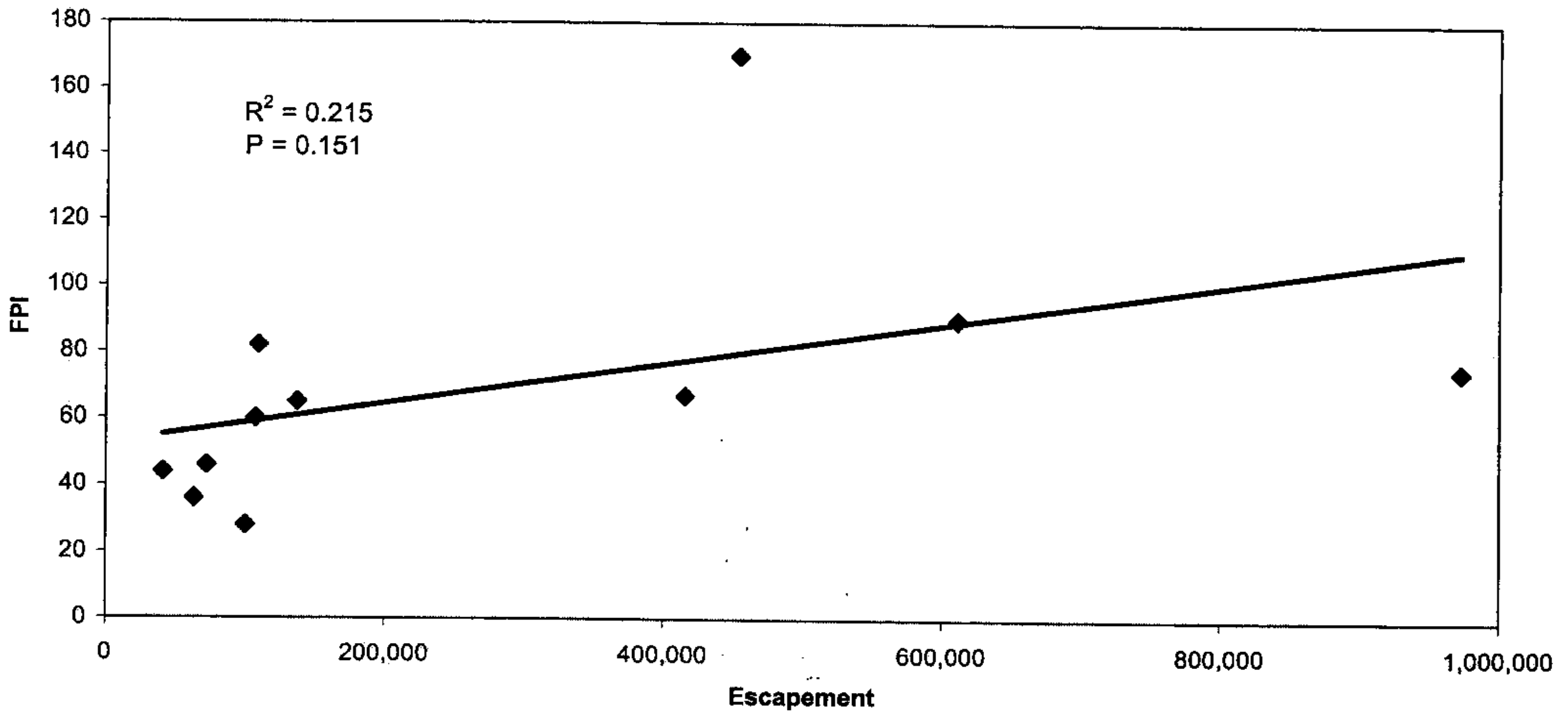


Figure 28. Comparison of FPI (3 day average after "lock-in" occurred) and escapement of sockeye salmon prior to the date of "lock-in", Egegik River, 1991-2001.

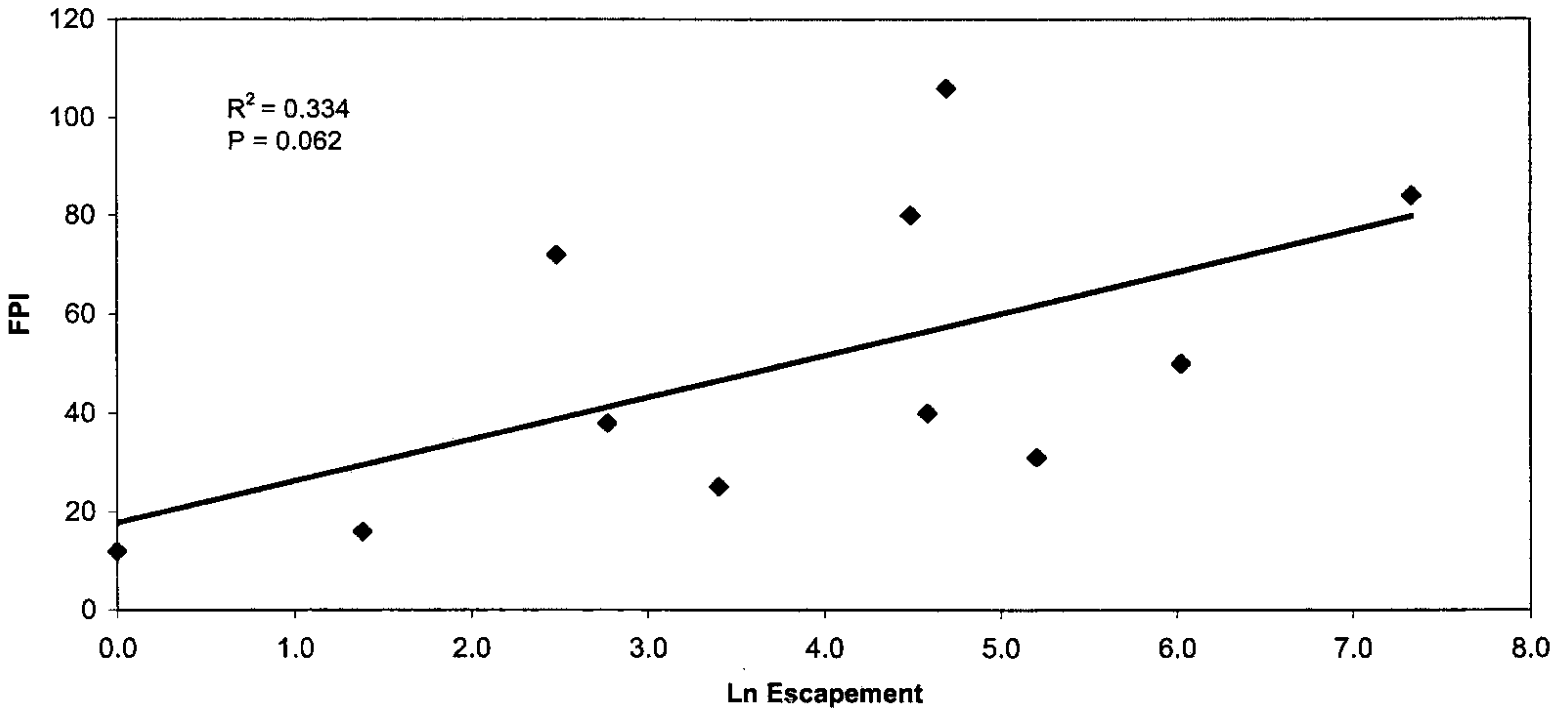


Figure 29. Comparison of FPI (3 day average after "lock-in" occurred) and the log of the escapement of sockeye salmon prior to the date of "lock-in Ugashik River, 1991-2001.

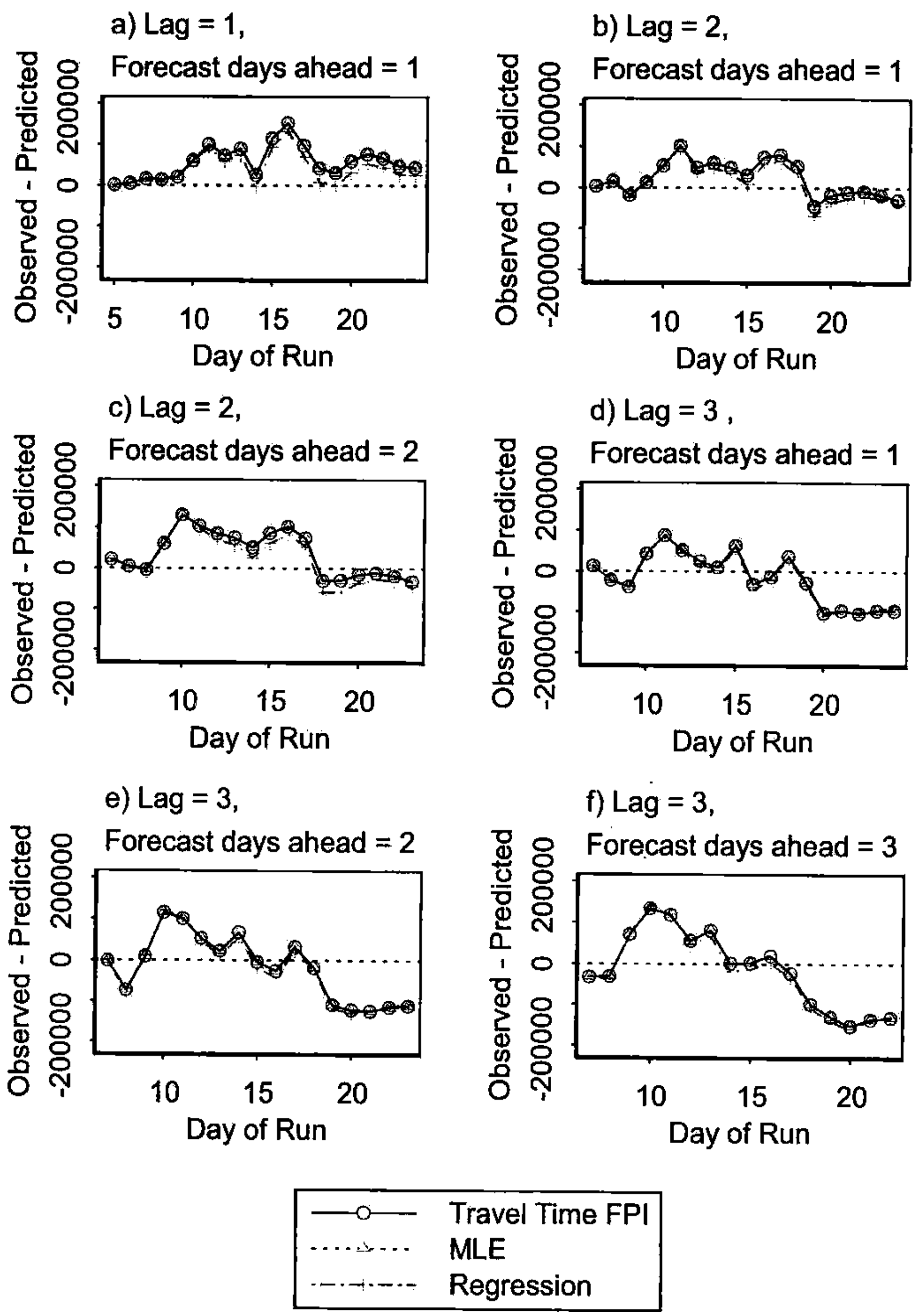


Figure 30. Deviations of the predicted cumulative escapement from the actual cumulative escapement (observed – predicted) using travel-time (FPI), maximum likelihood (MLE) and regression methods, Kvichak River, 2001.

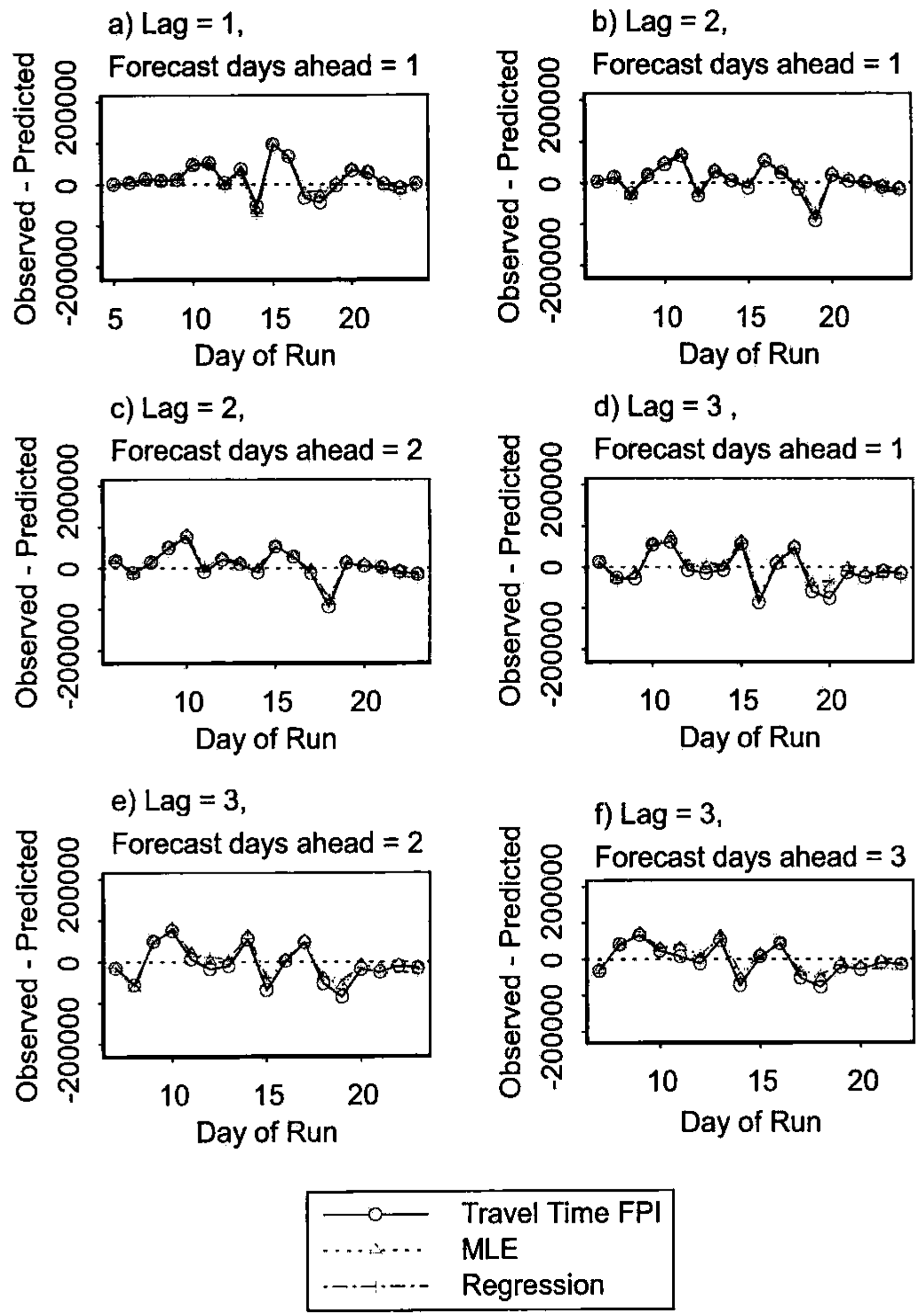


Figure 31. Deviations of the predicted daily escapement from the actual daily escapement (observed – predicted) using travel-time (FPI), maximum likelihood (MLE) and regression methods, Kvichak River, 2001.

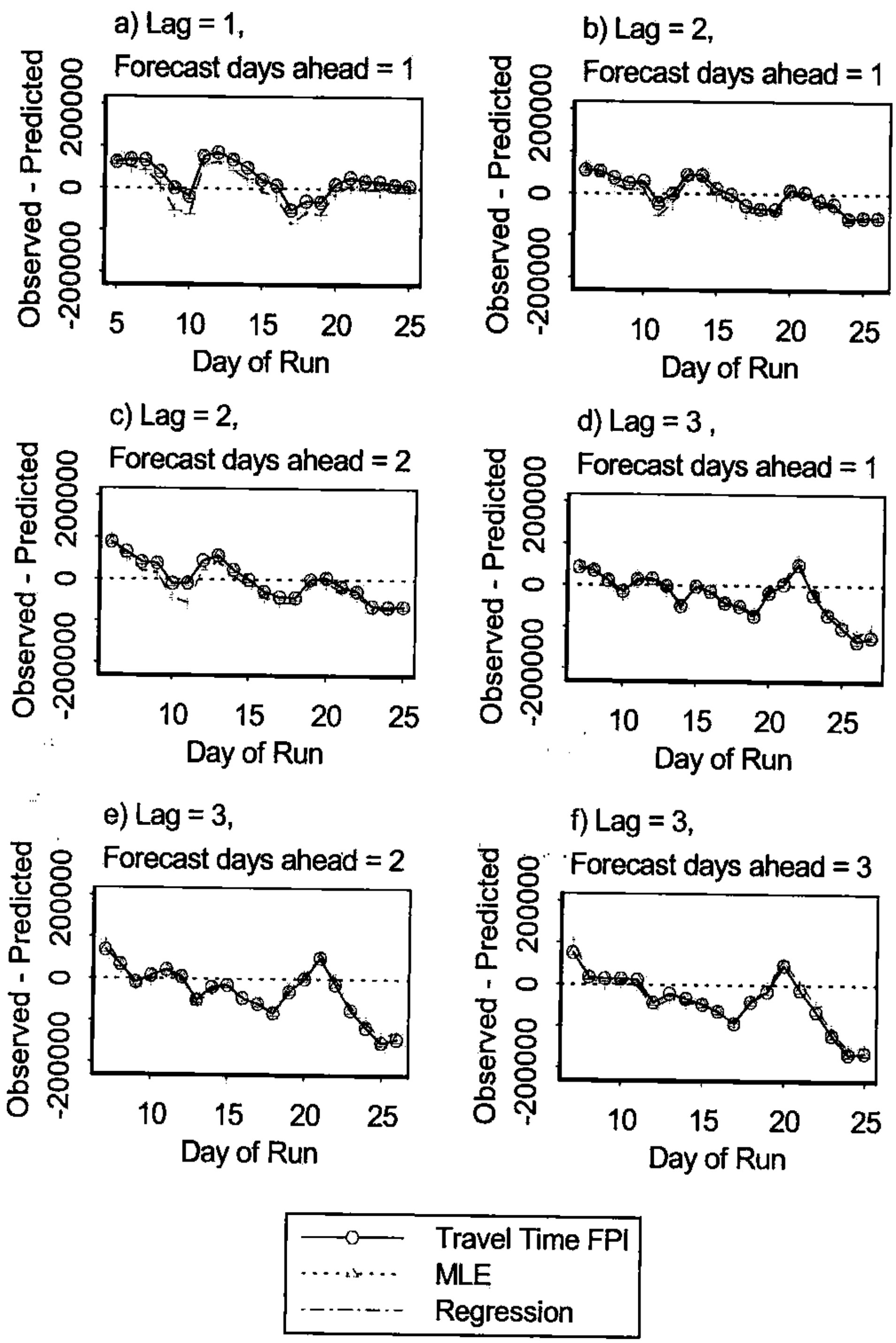


Figure 32. Deviations of the predicted cumulative escapement from the actual cumulative escapement (observed – predicted) using travel-time (FPI), maximum likelihood (MLE) and regression methods, Egegik River, 2001.

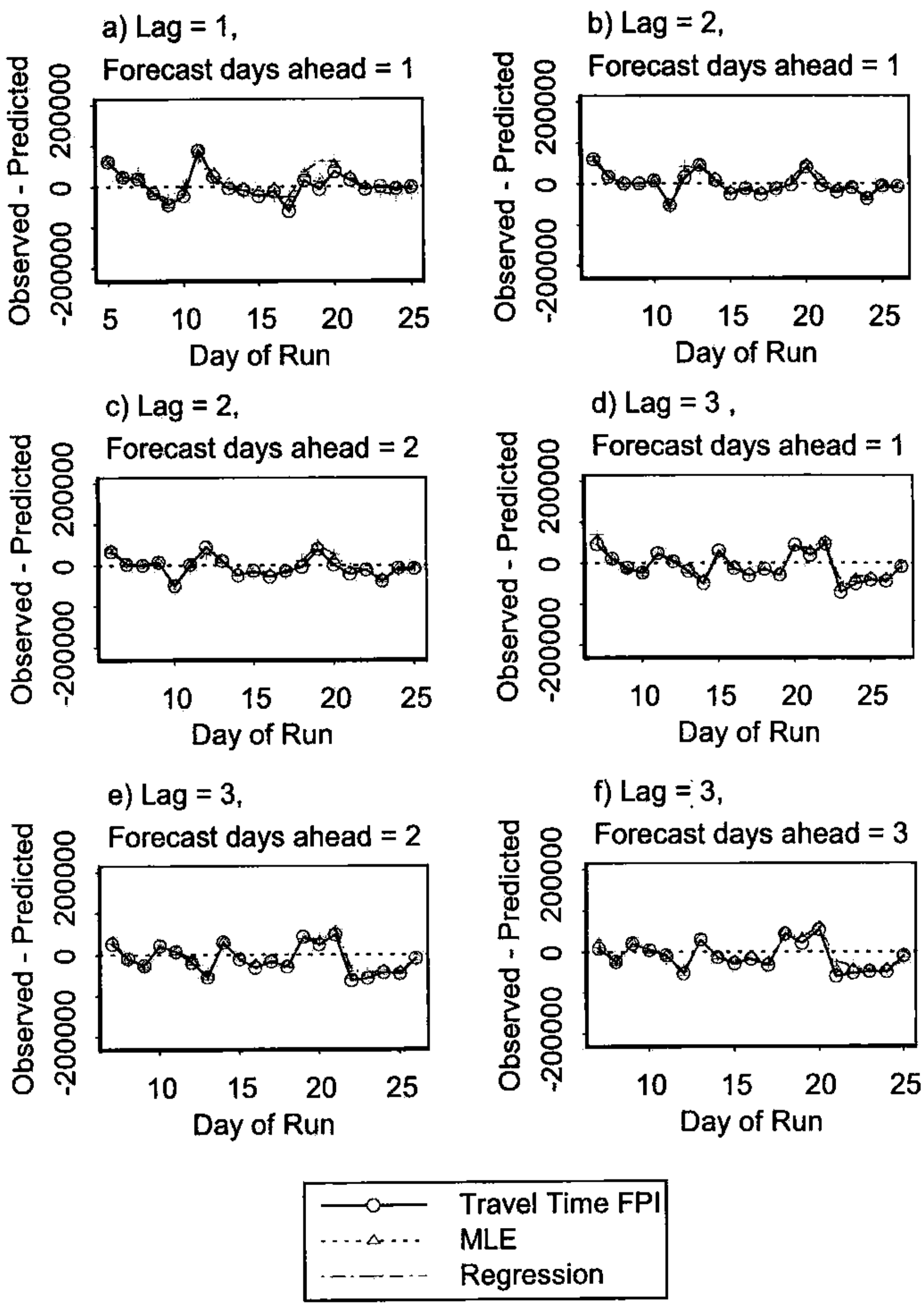


Figure 33. Deviations of the predicted daily escapement from the actual daily escapement (observed – predicted) using travel-time (FPI), maximum likelihood (MLE) and regression methods, Egegik River, 2001.

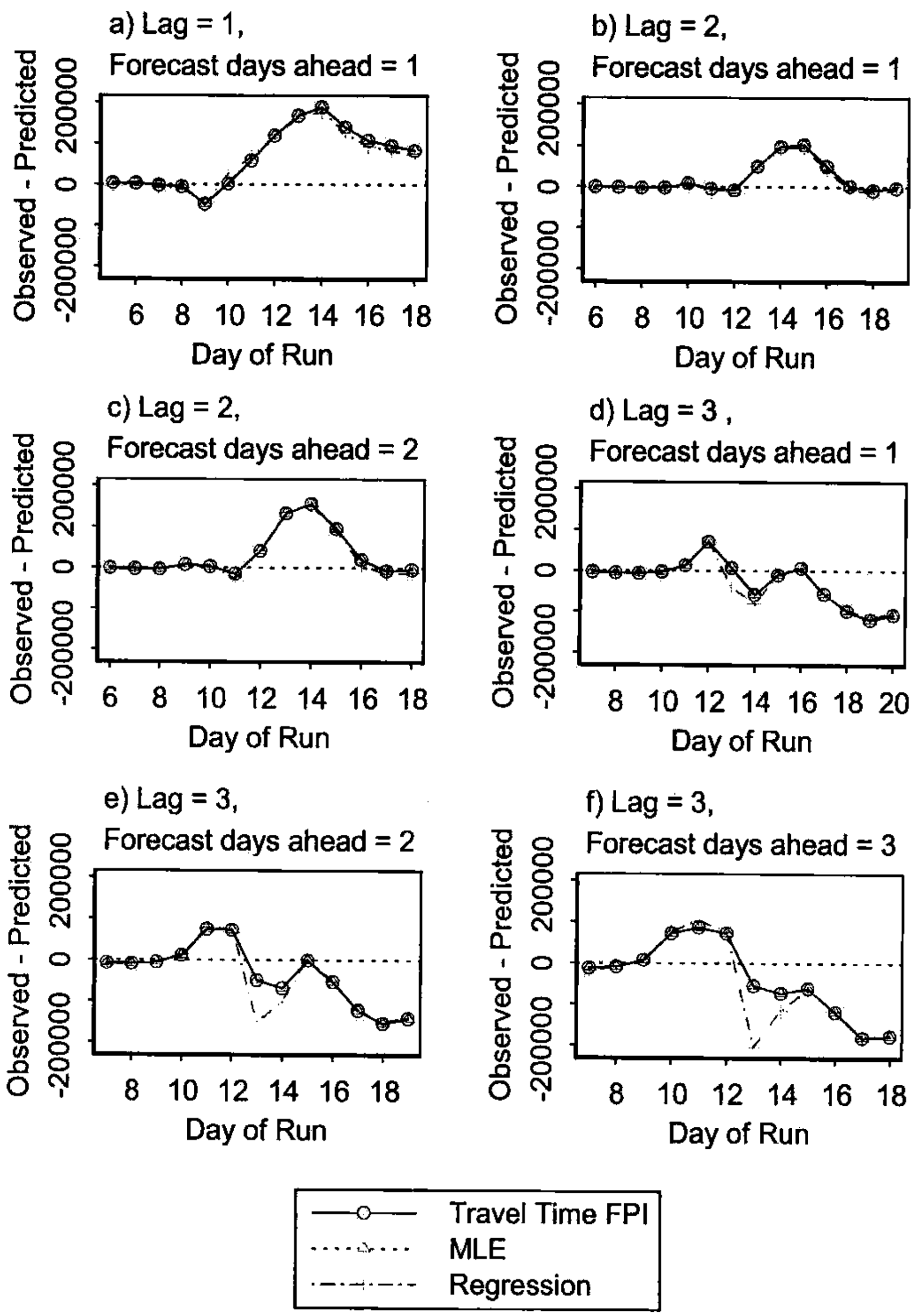


Figure 34. Deviations of the predicted cumulative escapement from the actual cumulative escapement (observed – predicted) using travel-time (FPI), maximum likelihood (MLE) and regression methods, Ugashik River, 2001.

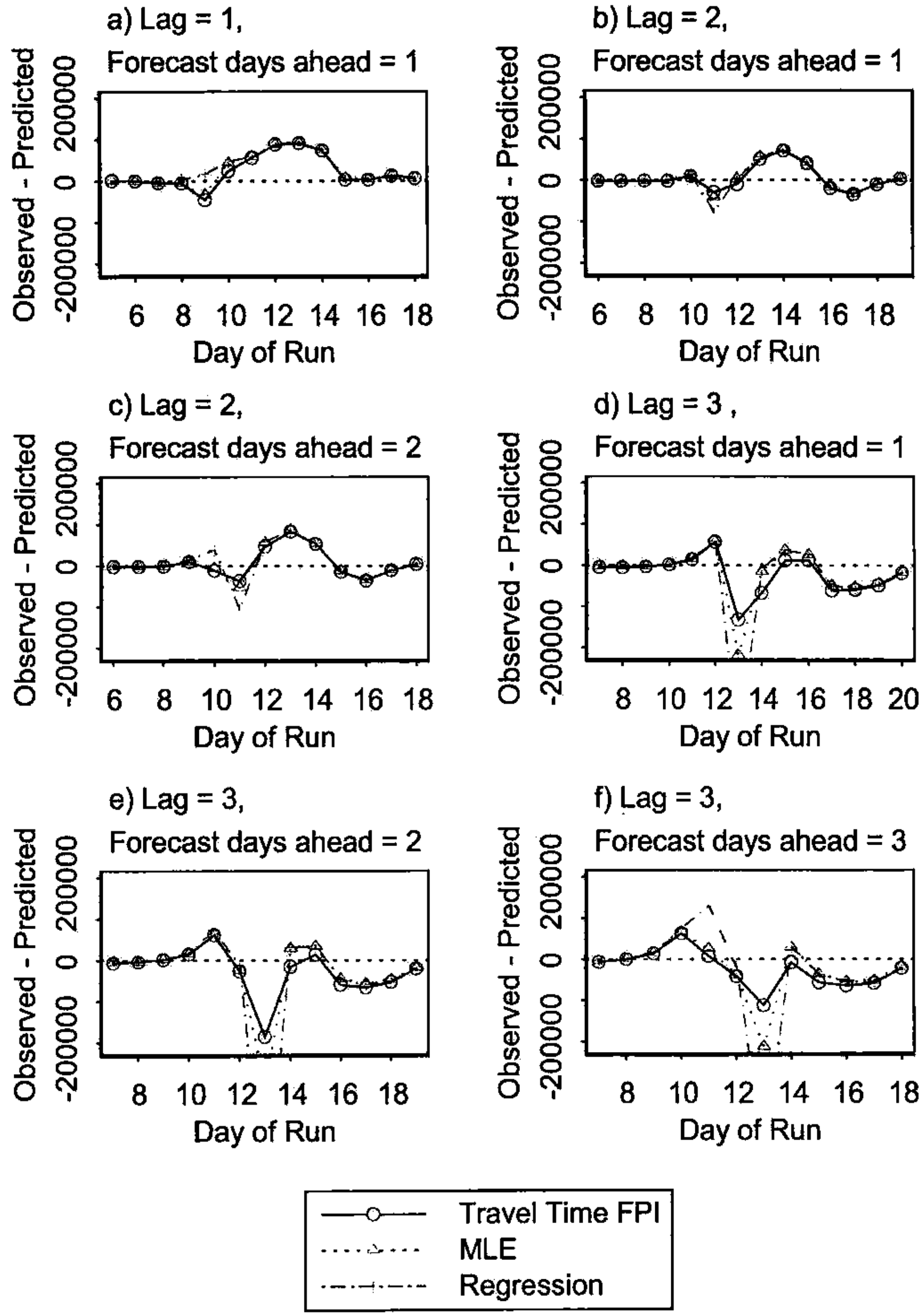


Figure 35. Deviations of the predicted daily escapement from the actual daily escapement (observed – predicted) using travel-time (FPI), maximum likelihood (MLE) and regression methods, Ugashik River, 2001.

Appendix A.1. Historical comparison of mean daily water temperature and FPI at the Kvichak River test fish site, 1989-2001.

	Year																									
	1989		1990		1991		1992		1993		1994		1995		1996		1997		1998		1999		2000		2001	
Date	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI
6/19					9.0	119																				
6/20			10.0	113	9.0	119	15.0	112																		
6/21	12.0	106	11.0	113	9.0	119	11.5	112					12.5	111	-	21	15.0	84	8.9	81	11.0	106	12.0	105	14.0	70
6/22	10.5	106	11.0	113	10.5	119	-	112	15.0	111	12.0	108	13.0	111	14.0	21	13.5	84	8.9	81	11.0	106	12.0	105	15.0	70
6/23	10.0	106	10.0	113	10.0	119	13.0	112	14.0	111	12.0	108	13.0	111	14.0	21	14.0	84	10.0	81	12.0	106	13.0	105	16.0	70
6/24	10.8	106	11.0	113	10.5	119	12.0	112	13.5	111	12.0	108	13.0	111	13.5	21	13.5	84	11.5	81	11.0	106	13.0	105	15.0	70
6/25	12.5	106	11.0	113	10.5	119	11.0	112	14.0	111	11.0	108	13.0	111	12.0	21	13.0	84	12.2	81	11.0	106	13.0	105	15.0	50
6/26	11.5	106	11.5	113	12.0	119	11.0	112	14.5	26	10.5	108	13.0	111	11.0	21	13.5	84	12.8	81	11.0	106	13.0	105	15.0	50
6/27	12.0	106	11.5	113	10.5	119	11.5	112	13.5	67	11.0	108	12.5	111	12.0	21	13.0	84	12.5	81	11.0	106	13.0	105	14.0	32
6/28	10.5	106	12.0	113	11.0	68	-	112	13.5	120	11.5	108	11.5	111	12.0	228	14.0	84	12.5	81	12.0	106	12.0	105	14.0	23
6/29	12.0	82	12.0	113	11.5	55	-	74	14.0	150	11.0	108	11.5	111	13.0	234	14.0	84	14.5	76	11.5	106	13.0	105	-	16
6/30	-	82	12.0	76	11.0	39	-	74	13.0	121	11.5	108	11.5	115	12.0	238	15.5	84	14.5	68	12.0	106	12.0	105	14.0	19
7/01	-	112	12.0	28	11.0	45	13.0	94	13.5	124	13.0	109	12.0	119	13.0	264	16.0	84	14.5	58	12.0	106	13.0	105	13.0	34
7/02	12.5	129	12.0	24	11.0	47	12.0	73	14.0	112	13.5	108	13.0	122	13.0	125	16.5	84	14.0	53	12.0	106	13.0	49	13.0	36
7/03	12.5	136	12.5	93	11.0	51	13.0	50	13.0	122	13.0	108	14.0	136	12.0	230	17.0	99	12.5	80	12.0	106	12.0	49	13.0	43
7/04	14.0	128	13.0	93	11.0	64	13.5	58	12.5	105	12.0	129	14.0	138	12.0	175	17.5	109	13.5	69	12.0	106	12.0	54	12.0	35
7/05	14.0	131	12.0	104	11.0	68	13.0	56	13.0	113	11.5	116	14.0	142	13.5	175	17.0	79	13.0	84	12.0	106	13.0	55	12.0	35
7/06	13.0	135	12.0	133	12.0	68	13.0	75	13.5	121	11.5	128	14.0	143	14.0	154	17.0	61	13.0	84	12.0	80	14.0	56	12.0	35
7/07	11.8	145	12.0	148	11.0	70	13.5	86	13.0	119	11.0	141	13.5	137	14.5	146	18.0	64	12.8	81	12.0	79	13.0	56	13.0	38
7/08	12.0	142	12.0	156	11.0	72	13.5	92	13.0	116	11.0	145	13.0	146	14.0	112	18.0	67	12.8	80	11.5	69	13.0	56	12.0	39
7/09	12.3	143	12.0	158	11.0	70	14.0	91	14.0	113	11.0	137	14.0	149	14.0	108	17.0	66	12.8	81	13.0	70	14.0	54	12.0	42
7/10	12.0	144	12.0	157	11.5	68	13.5	90	14.0	108	11.0	143	14.0	152	14.0	105	15.0	59	12.8	85	13.0	76	14.0	55	11.0	37
7/11	12.3	144	12.0	158	11.0	69	13.0	96	14.5	91	11.5	144	13.5	158	14.0	93	15.5	57	12.8	95	13.0	79	14.0	56	12.0	37
7/12	13.0	144	13.0	159	12.0	68	14.0	110	14.0	96	12.0	144	14.0	155	14.0	80	15.5	56	13.0	100	13.0	80	14.0	62	12.0	35
7/13	13.0	144	13.0	161	11.0	69	14.0	123	14.0	87	12.0	143	13.5	157	14.0	83	15.5	57	14.0	99	13.0	86	14.0	66	12.0	35
7/14	13.0	144	13.0	149	11.5	70	14.0	106	14.0	88	12.0	143	14.0	156	14.0	83	15.0	58	13.0	95	13.0	86	14.0	53	12.0	35
7/15	12.0	141	13.0	149	11.0	70	13.5	109	15.5	88	13.5	142	14.0	153	14.0	82	15.0	58	13.0	92	13.0	85	14.0	56	12.0	34
7/16	12.0	142			11.0	71	13.5	106	15.0	88			14.0	154	14.0	80	15.0	58	14.0	91	12.0	85	14.0	51		
7/17					11.0	71			15.0	86			14.0	154	14.0	77					12.0					
7/18									15.5	85			13.0	154												
7/19									15.5	85																
7/20									16.0	84																
Min	10.0	82	10.0	24	9.0	39	11.0	50	12.5	26	10.5	108	11.5	111	11.0	21	13.0	56	8.9	53	11.0	69	12.0	49	11.0	16
Mean	12.1	124	11.9	118	10.8	81	13.0	95	14.0	103	11.8	123	13.2	134	13.3	112	15.4	75	12.7	82	12.0	95	13.1	76	13.1	41
Max	14.0	145	13.0	161	12.0	119	15.0	123	15.5	150	13.5	145	14.0	158	14.5	264	18.0	109	14.5	100	13.0	106	14.0	105	16.0	70

Appendix A.2. Historical comparison of mean daily water temperature and FPI at the Egegik River test fish site, 1989-2001.

	Year																									
	1989		1990		1991		1992		1993		1994		1995		1996		1997		1998		1999		2000		2001	
Date	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI
6/12			8.5	59																						
6/13			-	59																						
6/14			-	59																72	-	62	9.0	77	8.0	76
6/15	10.0	61	-	59					10.5	72	-	73			12.0	80	-	80	10.5	72	-	62	9.0	77	9.0	76
6/16	10.5	61	-	59	-	70	-	72	11.5	72	-	73	12.0	79	11.0	80	-	80	10.5	72	-	62	9.0	77	11.0	76
6/17	11.0	61	-	59	-	70	10.0	72	12.0	72	9.0	73	12.0	79	12.0	80	11.5	80	12.0	72	-	62	9.0	77	12.0	76
6/18	12.3	61	-	59	-	70	10.0	72	12.5	72	10.0	73	11.5	79	13.0	80	15.5	80	10.0	72	9.0	62	9.0	77	15.0	76
6/19	11.0	61	-	59	-	70	10.0	72	13.0	72	11.0	73	10.0	79	14.0	80	12.5	80	10.0	72	9.5	62	9.0	77	14.0	79
6/20	10.8	61	-	59	10.0	70	10.5	72	13.0	72	11.0	73	10.0	79	11.0	80	12.5	80	9.0	72	9.5	62	9.0	77	14.0	52
6/21	10.0	61	-	59	9.0	70	10.5	72	14.0	72	10.5	73	11.0	79	11.0	80	11.5	80	11.0	72	9.0	62	9.0	77	13.0	46
6/22	9.8	61	-	59	-	70	10.0	72	13.0	72	10.5	73	11.0	79	11.0	80	13.5	80	8.5	72	8.5	62	9.0	77	14.0	58
6/23	9.3	61	-	59	11.0	70	12.5	72	11.5	230	10.5	73	10.5	79	10.0	80	14.5	31	8.5	72	8.0	62	11.0	77	14.0	65
6/24	9.0	61	9.0	59	-	70	12.5	72	13.0	138	10.0	73	9.0	79	12.0	45	15.0	27	9.0	46	9.5	62	11.0	77	14.0	66
6/25	9.3	57	9.0	15	-	70	12.0	72	14.0	141	8.0	73	9.0	79	9.0	50	14.0	26	10.0	46	9.5	62	11.0	77	14.0	66
6/26	9.5	26	9.0	14	-	70		57	12.0	165	8.0	82	11.0	36	13.0	44	13.0	27	10.5	41	-	62	11.0	77	13.0	68
6/27	10.0	26	-	14	-	70	11.0	71	11.0	175	8.5	95	12.0	70	11.0	30	13.0	31	11.0	41	9.5	62	13.0	77	14.0	59
6/28	10.5	28	10.0	8	-	24	11.0	53	10.5	151	11.0	68	11.0	89	15.0	30	15.0	40	11.5	41	11.5	62	13.0	77	15.0	62
6/29	11.5	26	8.0	22	-	33	11.5	62	10.5	98	11.5	71	11.0	101	16.0	41	15.0	42	12.5	43	10.0	62	13.0	90	14.0	69
6/30	12.0	27	-	48	10.0	52	10.0	80	11.0	97	12.0	68	11.0	96	16.0	40	15.0	42	12.5	45	10.5	62	11.0	89	13.0	69
7/01	10.3	34	-	88	9.0	33		74	10.5	97	11.0	81	11.0	105	15.0	39	15.0	45	13.0	55	9.0	62	11.0	91	12.0	66
7/02	9.0	23	-	48	10.0	29	12.0	79	10.0	102	10.0	76	12.0	93	15.0	42	15.0	43	13.5	55	8.5	62	11.0	87	13.0	65
7/03	12.0	38	-	93	12.0	52	13.0	78	10.0	101	9.0	86	13.0	93	15.0	44	14.5	42	11.0	43	8.5	62	11.0	90	13.0	62
7/04	10.5	50	11.0	99	12.5	60	12.0	77	10.5	99	9.5	116	13.5	102	15.0	46	17.5	40	11.5	55	9.5	62	10.0	90	12.0	60
7/05	10.0	52	-	108	11.5	60		82	10.5	106	10.0	112	14.0	107	12.0	48	16.5	38	12.0	54	9.5	62	10.0	98	12.0	60
7/06	8.8	66	11.0	115	10.5	75	11.0	85	11.0	108	9.5	106	11.5	98	11.0	46	18.0	38	11.5	57	9.0	62	11.0	80	12.0	64
7/07	8.8	74	10.5	113	9.5	76	11.0	78	11.0	111	10.0	119	11.0	98	12.0	48	18.5	49	12.5	62	10.0	75	11.0	78	12.0	63
7/08	9.3	61	-	114	10.0	79	12.0	82	11.5	115	11.0	126	12.0	102	13.0	50	17.0	49	11.5	60	10.5	75	11.0	79	13.0	62
7/09	11.3	59	11.5	114	11.5	81	13.0	72	12.5	76	11.0	142	12.5	102	13.0	53	15.0	43	11.0	58	11.5	75	11.0	79	14.0	61
7/10	12.5	52	12.0	119	-	80	13.0	81	13.0	75	9.0	147	12.0	101	13.0	64	14.0	43	11.5	63	10.0	-	12.0	79	12.0	59
7/11	12.0	52	9.5	123	9.0	81	13.0	89			11.0	138	13.0	101	14.0	71	14.0	50	11.5	61	12.5	82	13.0	83	12.0	59
7/12	11.3	51	-	117	-	82					11.0	137	13.0	100	14.0	72	14.5	52	12.0	61	12.0	82	13.0	81	11.0	58
7/13			-	119															12.0	65	-	82	15.0	80		
Min	8.8	23	8.0	8	9.0	24	10.0	53	10.0	72	8.0	68	9.0	36	9.0	30	11.5	26	8.5	41	8.0	62	9.0	77	8.0	46
Mean	10.4	50	9.9	71	10.4	64	11.4	74	11.7	106	10.1	92	11.5	88	12.8	58	14.7	51	11.1	59	9.8	65	10.8	81	12.7	65
Max	12.5	74	12.0	123	12.5	82	13.0	89	14.0	230	12.0	147	14.0	107	16.0	80	18.5	80	13.5	72	12.5	82	15.0	98	15.0	79

Appendix A.3. Historical comparison of mean daily water temperature and FPI at the Ugashik River test fish site, 1989-2001.

	Year													
	1989		1990		1991		1992		1993		1994		1995	
Date	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI
6/20			10.0	37										
6/21			10.0	37	-	37								
6/22			10.0	37	12.0	37								
6/23			10.0	37	12.0	37	12.0	43						
6/24	10.3	35	10.8	37	12.5	37	12.0	43	14.0	49			9.5	80
6/25	9.8	35	10.5	37	11.5	37	12.0	43	13.5	49	12.0	53	10.0	80
6/26	10.0	35	10.5	37	10.5	37	12.0	43	13.5	49	11.0	53	11.0	80
6/27	10.0	35	10.5	37	11.5	37	12.5	43	14.0	49	11.5	53	11.5	80
6/28	11.0	35	10.0	37	11.5	37	12.5	43	13.5	49	11.0	53	10.0	80
6/29	11.8	35	11.0	37	10.0	37	13.0	43	13.5	49	12.0	53	11.5	80
6/30	12.0	35	12.5	37	10.0	37	12.0	43	14.0	49	14.0	53	12.5	80
7/01	10.0	35	12.5	37	9.5	37	12.0	43	12.5	49	14.0	53	12.0	80
7/02	10.0	35	-	37	10.0	37	12.0	43	13.0	9	13.0	53	13.0	80
7/03	12.0	35	-	37	10.0	37	12.0	43	12.0	15	12.5	53	12.0	80
7/04	13.3	35	-	37	11.5	37	12.0	43	13.0	11	11.5	53	12.0	80
7/05	14.8	35	13.0	37	11.5	37	13.0	43	12.5	17	11.5	53	12.5	80
7/06	13.8	35	12.8	37	12.0	37	12.0	43	12.0	15	12.0	53	12.0	80
7/07	13.5	35	12.8	12	12.0	37	13.0	12	12.0	5	13.5	53	12.0	74
7/08	13.0	16	14.3	16	11.0	37	13.5	15	12.0	19	13.0	53	12.0	84
7/09	13.5	15	13.5	19	12.0	73	13.5	20	13.0	71	13.5	53	12.0	81
7/10	13.8	16	13.3	20	10.5	40	14.0	18	14.0	79	13.5	90	12.5	74
7/11	14.0	18	14.0	18	11.5	36	14.0	18	15.0	85	13.0	90	11.5	70
7/12	14.8	39	15.0	62	12.5	55	14.0	19	15.0	87	13.5	137	13.5	70
7/13	14.0	49	14.0	38	14.0	68	14.0	21	-	87	14.5	119	12.5	68
7/14	13.5	42	15.0	37	12.5	80	14.0	26			14.5	99	13.0	58
7/15	13.0	42	14.8	36	13.0	89	14.0	51			13.0	98	13.0	53
7/16	13.0	43	15.0	36			14.0	62			13.5	93	12.5	58
7/17	12.5	45	14.8	36			14.0	95			12.0	94	12.0	66
7/18	13.3	43	15.0	38			14.0	99					13.0	77
7/19	12.0	46	15.5	37									13.0	81
7/20	12.0	46	14.8	35										
7/21	11.8	46												
Min	9.8	15	10.0	12	9.5	36	12.0	12	12.0	5	11.0	53	9.5	53
Mean	12.4	36	12.7	34	11.5	44	13.0	41	13.3	45	12.8	70	12.0	75
Max	14.8	49	15.5	62	14.0	89	14.0	99	15.0	87	14.5	137	13.5	84

	Year											
	1996		1997		1998		1999		2000		2001	
Date	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI	Temp	FPI
6/20												
6/21												
6/22												
6/23	-	95										
6/24	11.5	95	15.5	30			12.0	54	12.0	58	15.0	40
6/25	11.5	95	16.0	30			12.0	54	12.5	58	14.0	40
6/26	14.0	95	15.5	30	14.0	54	11.5	54	13.5	58	12.0	40
6/27	13.5	95	15.5	30	11.5	54	11.0	54	14.0	58	14.0	40
6/28	14.0	95	16.0	30	13.5	54	12.5	54	14.0	58	14.0	40
6/29	14.0	95	16.5	30	14.0	54	12.0	54	14.0	58	15.0	40
6/30	14.0	95	17.0	30	14.0	54	13.0	54	13.5	58	14.0	40
7/01	-	95	17.0	30	14.5	54	12.5	54	13.0	58	14.0	40
7/02	-	95	17.0	30	14.0	54	11.0	54	12.0	58	14.0	40
7/03	14.0	95	17.0	30	13.5	54	10.0	54	12.5	58	14.0	40
7/04	14.0	95	17.0	30	13.0	54	11.5	54	12.0	58	14.0	40
7/05	13.5	41	17.5	30	13.0	54	10.5	54	12.5	58	13.0	23
7/06	14.0	40	18.0	30	12.0	54	11.0	54	13.5	58	12.0	23
7/07	13.0	40	18.5	44	12.5	43	14.0	54	13.5	31	13.0	28
7/08	14.0	40	18.0	36	14.0	53	12.0	54	13.5	31	13.0	24
7/09	13.5	39	17.5	33	14.0	53	12.5	54	13.5	32	12.0	24
7/10	14.5	35	18.0	31	13.5	53	-	54	13.5	32	12.0	28
7/11	14.5	34	18.0	30	13.0	53	13.5	54	13.5	32	12.0	39
7/12	14.0	33	17.0	32	13.0	64	14.5	54	15.0	34	11.0	40
7/13	13.5	32	17.0	33	13.0	76	14.0	54	16.0	36	12.0	37
7/14	14.0	33	17.0	24	13.0	76	14.0	54	16.0	36	11.0	32
7/15	13.0	33	17.0	25	15.0	78	14.0	54	16.0	36	12.0	31
7/16	14.0	37	16.5	23	14.5	73	15.0	54	14.0	36	11.0	31
7/17	14.5	38	16.0	22	15.0	71	15.0	83	13.0	33		
7/18	14.0	36	16.0	22	14.0	71	14.0	84	13.0	35		
7/19									11.5	40		
7/20									11.0	42		
7/21												
Min	11.5	32	15.5	22	11.5	43	10.0	54	11.0	31	11.0	23
Mean	13.7	64	16.9	30	13.5	59	12.6	56	13.4	46	13.0	35
Max	14.5	95	18.5	44	15.0	78	15.0	84	16.0	58	15.0	40